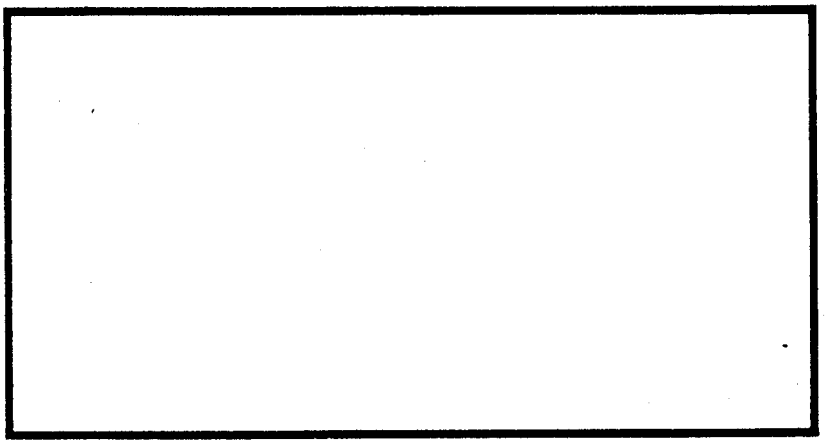

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GCA/LSY/91S-8

A COMPARATIVE ANALYSIS OF THE LABOR FORCE STRUCTURE AT ARNOLD ENGINEERING DEVELOPMENT CENTER AND THE NAVAL AIR PROPULSION CENTER

THESIS

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THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
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In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Cost Analysis

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Dennis L. Mitchell

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Abstract

This study compared the costs and benefits of the manning structure of two DoD ground test facilities, Arnold Engineering Development Center (AEDC) and the Naval Air Propulsion Center (NAPC). Total costs included all fixed and joint costs for each facility. The purpose of the study was to determine (1) the existence and extent of cost differences between the two facilities, (2) reasons for these cost differences, and (3) their impact. The results indicate that AEDC is a lower cost facility, on a total cost basis. This lower cost is primarily a function of varying manning to meet required workload. In addition, AEDC has both higher marginal total costs and higher marginal labor costs. As a result, AEDC is more efficient at lower levels of workload. A literature search revealed several possible benefits, or lack thereof, associated with using private sector labor to accomplish government tasks. A subjective evaluation of historical data, and current procedures was made to determine if these applied to the labor force at AEDC. The overall assessment was that some of the benefits and drawbacks do exist. The impact is that the benefits outweigh the drawbacks.

A COMPARATIVE ANALYSIS OF THE LABOR FORCE STRUCTURE AT ARNOLD ENGINEERING DEVELOPMENT CENTER AND THE NAVAL AIR PROPULSION CENTER

I. Introduction

General Issue

Arnold Engineering Development Center (AEDC) is one of the world's largest and most complete aerodynamic propulsion testing complexes. It consists of more than 40 individual test and research facilities, valued at $3.4 billion. Constructed in 1951, it is the Air Force's primary ground test facility. As a national test facility, AEDC conducts tests, engineering analyses, and technical evaluations for research, system development, and operational programs of the Air Force, Department of Defense, other governmental agencies, major defense contractors, and allied foreign governments. From the beginning, the Air Force has used contractor labor to accomplish AEDC's mission. Currently, 90% of the labor force employed by AEDC is private contractor. Like other DOD test facilities, AEDC charges its customers for the cost of performing test projects. In fact, over 45% of the AEDC annual operating budget is in the form of customer payments (Smith, 1991). Recent reductions in budgets of these customers have compelled AEDC to review

its current method of operations, including its manpower costs. One question arising from this review is "How do the AEDC total labor costs compare with those of a similar DoD facility?"

With regard to the above, the Department of Defense Inspector General (DoD/IG) investigated the operations at AEDC in 1989. The primary focus of the investigation was a comparison of AEDC labor costs with those of the Navy's Naval Air Propulsion Center (NAPC) for similar test projects. The DoD/IG concluded that for similar engine test projects, AEDC labor was approximately 10% higher on a "per/hour" basis. In addition, AEDC required more labor hours to accomplish the same task. The combined effect was that AEDC labor costs were 33% higher than NAPC for the same task. This study criticized the use of contractor personnel for ground test mission accomplishment based on high cost (Milhiser, 1991). The DoD/IG findings were based on a sample of three turbine engine tests accomplished at each facility, which were not exactly identical. Actual manhour charges for these three "comparable" tests were adjusted in an attempt to equate the tests performed at the two facilities. The cost of these revised manhours was then estimated. This estimated cost formed the basis of the DoD/IG findings. In addition, the report focused only on those costs charged to the customer. Joint costs, and fixed

costs were ignored. Finally, the DoD/IG report generalized the specific findings for these three tests to the entire scope of effort at AEDC.

Because the DOD/IG study used a small sample, a "cost to the customer" approach, and generalized the findings to describe overall AEDC operations, further analysis is required. An overall, total cost (including non-monetary costs) comparison is required to determine (1) if the use of contractor labor indeed increases overall ground test cost at AEDC, relative to NAPC and (2) if so, are there any benefits derived from this additional expense.

Investigative Questions

There are two main questions which make up the cost/benefit analysis. The first is the question of cost. The second is qualitative in nature, and deals primarily with benefits, or the lack thereof. The two questions are:

1. What are the results of a cost comparison of the use of contracted labor resources at AEDC vs the use of in-house labor at NAPC? Labor costs will include all direct and indirect compensation.

2. What are the benefits and drawbacks of using contracted labor resources at AEDC, and how do they compare to those associated with using in-house labor at NAPC? The qualitative aspects considered are: (1) the number of errors resulting in re-accomplishment of particular tests, (2) flexibility in manning to meet required workload, (3)

the level of specialization and expertise of the labor force, (4) the existence of innovations, (5) management control, (6) dependence on the private sector, (7) potential for conflicts of interest, and (8) the timeliness of responses to customer requests.

Scope and Limitation of the Research

A complete comparison of the costs, benefits, and drawbacks of contracted ground test services compared to services provided by in-house employees would require analysis of all types of ground test facilities, at all DOD locations doing ground test work. There are currently 22 such facilities (Milhiser, 1991). This research examines the costs and benefits as they pertain to the operation of only two such facilities. This research focuses on specific examples, cost comparisons, and exploration of benefits for Arnold Engineering Development Center, and the Naval Air Propulsion Center.

II. Background of the Problem/Review of the Literature

Chapter Overview

This chapter presents a review of the subject of the public sector's contracting for services. The professional services industry, as a whole, employs an estimated 3 million people. Because so many different activities might fall under the label of consultant, it is difficult to estimate the number of consultants used by the Department of Defense. However, one congressional staffer, working from DoD supplied data, estimates the DoD paid for approximately 1.4 million consultant work-years in 1989. That compares to an active duty military population during the same period of about 2.1 million (Grier, 1987:33). This chapter first reviews the history of contracting for services by the Federal Government. Second, the chapter presents a discussion of the current guidance concerning privatization of government services. Third, the chapter concludes with a discussion of the advantages and disadvantages of privatization.

History of Privatization

The privatization of government services is not a new phenomenon. "Its lineage has been largely, but not totally, Republican. In 1955, President Eisenhower's Bureau of the Budget announced the governmental policy of reliance on commercial sources for goods and services" (Wheeler,

1987:30). The privatization policy was officially stated when the Bureau of the Budget issued its first authoritative document on commercial activities in 1966. (Wheeler, 1987:30). This document, Circular A-76, became the guide for all privatization initiatives, and was developed to discourage the federal government from being in direct competition with private industry for goods and services (Dept. of the AF; 1989:1).

The intent of Circular A-76 was not to eliminate all government provision of goods, services, and facilities. However, it was suggested that a commercial activity remain an in-house effort only if it met at least one of four major criteria. First, national defense interests may require that the service be performed organically. An activity may be essential for training or experience in required military skills. Alternatively, retaining the activity may be necessary in order to provide appropriate rotation of personnel and for proper career progression. Second, a function may be retained in-house if there is no satisfactory commercial source available. Third, in-house performance may be justified as in the best interest of the organization, or because fourth, organic performance was deemed cost effective (Perfilio,1989:72).

Current Guidance

The Department of Defense continues to pursue the goals set forth by past administrations, and the Privatization

Council (Privatization Council, 1987:2). Privatization does not have a goal of eliminating the provision of government programs and services. Its goal is to improve the quality, efficiency, and affordability of government goods and services. In DoD privatization, both long term (one year or longer), and short term contracts are used. The use of long term contracts is justified by Circular A-76. Short term contracts use consultants for specialized tasks, professional services, and technical expertise.

Long Term Contracts.

The process defined in Circular A-76 is one specific technique which justifies the use of private firms to provide long term public goods and services (Grier, 1989:34). A-76 criteria are typically used to evaluate the desirability of contracting out labor intensive functions. The contracts are usually awarded for 1 year, with three or four 1-year options (Dept of the AF; 1989:1).

One problem with the A-76 guidance is determining what particular jobs should only be done by government employees. A second problem associated with the A-76 guidance is determining the costs of the services being provided to the government. The Office of Management and Budger (OMB) stipulates that a cost study will determine whether an operation will continue as a government function, or will be contracted out with a commercial source (Wheeler, 1987:30). The private sector cost is relatively easy to obtain by requesting proposals for a particular job. The government

cost of accomplishing a job, however, is difficult to determine. It is difficult to obtain reliable and useful data from employees who could lose their jobs due to contracting out. The employees "are asked to produce work descriptions for use in cost estimating. Predictably, these descriptions are often vague and incomplete, according to the General Accounting Office" (Grier, 1989:34). The third major problem with following the guidance of Circular A-76 is political. Congress makes many of the decisions as to which specific jobs will be contracted out. In recent years, lawmakers have enacted some 35 specific restrictions reserving certain functions for full government employees.

In spite of the above, privatization efforts have saved the government money and increased competition for the provision of government goods and services (Grier, 1989:34). The DoD has reportedly shared in the success of privatization efforts. "So far the Pentagon has privatized a total of about 40,000 jobs under the A-76 process, for an estimated annual savings of $613 million" (Grier, 1989:33). Therefore the A-76 program seems to be a useful tool for the privatization of many goods and services.

Short Term Criteria.

While the A-76 criteria seem to be relevant for evaluating continuing functions, they do not address the question of the periodic, or temporary activity. These activities, by their nature, do not yield themselves to the

A-76 process, with its long term replacement of in-house personnel with private sector labor.

There are occasions where organizations simply need a specific task accomplished. When military offices do not have ready access to in-house expertise for a particular project, they often turn to consultants (Grier, 1987:33). For example, faced with the need to design and manage a centralized data system to keep track of every F-16 around the world, the Air Force hired Dynamic Research Corporation. In another case, the Joint Chiefs of Staff brought in Decisions and Designs, Inc. to draw up a master plan for the use of new satellite navigation assets (Grier, 1987:33).

Whether services are privatized via the A-76 program, or by consultants in the short term, there are advantages and disadvantages to privatization. The following discussion explores each of these in detail.

Advantages and Disadvantages of Contracting Out

Both proponents and opponents of privatization agree that there are advantages and disadvantages to contracting out government services.

Advantages.

There are several advantages which are frequently attributed to privatization. These fall into two primary groups: qualitative advantages, and cost advantages. A primary qualitative advantage concerns the value of the product provided. One source of this value is said to be

the greater competence of contractor personnel. Consulting firms tend to have narrow fields of expertise, with a great depth of knowledge. Increasingly complicated weapon systems and operations within the DoD mean that day to day management requires increasing specialization and depth of knowledge. In many cases, hiring a contractor is the only means of successfully accomplishing a task (Lallitin, 1986:32). Another qualitative advantage concerns the innovation evidenced in the provision of the product, and the flexibility and responsiveness of the contractor (Lallitin,1986:32). Contractors may be more innovative due to the less bureaucratic structure of their firms, or due to a greater ability to identify and reward innovation. Contractors may be more flexible and responsive in the delivery of products or services because of greater flexibility in work rules, and hiring and firing decisions. This same flexibility may also create cost advantages for the contractor.

Disadvantages.

There are two major concerns which are frequently cited in the argument against privatization. The first of these is that there are some qualitative disadvantages to privatization. The second is an argument that contracting out government services is more costly in the long term.

There are many qualitative arguments against privatization. The first of these is that the use of private firms results in a loss of management control. A

key factor which leads to a loss of management control is sheer quantity of services performed by contractors. For example, an IG investigation of the Naval Sea Systems Command (NAVSEA) concluded that NAVSEA had become dependent on a contractor to accomplish daily management tasks (Grier, 1987:34). Opponents of privatization argue that due to a blurred division of responsibility, it is difficult to make government employees accountable, or to know who originated a policy position (Goldstein, 1990:31).

A second qualitative disadvantage of privatization is that contracting out over a long period of time leads to a loss of in-house expertise. Some agencies now admit that years of contracting out critical government functions have drained the technical expertise available in the governmental ranks (Goldstein, 1990:31).

> Low salaries have encouraged the exodus of federal experts, robbing agencies of the capability to perform key tasks and diminishing their ability to evaluate work done by private firms on which they now must rely. (Goldstein, 1990, 31)

For example, the Environmental Protection Agency (EPA) Office of Toxic Substances has contracted out virtually every staff function in the office except that of the director (Goldstein, 1990,31).

A third qualitative disadvantage of privatization is that long term use of private sector labor, combined with the loss of expertise, creates an increased dependence on the contractor (Goldstein, 1990:30). Contractors have become so central to some agencies' operations that they end

up making the decisions for the organization. For example, since 1980, the EPA has contracted out the operation of the Superfund hotline. This hotline answers telephone questions from other government agencies, industry, and private individuals about complex hazardous waste laws. Callers are not normally informed that they are speaking to private contractors, and not agency personnel. In many cases, the contractor ends up interpreting federal statutes on behalf of the EPA. The problem is a lack of responsibility for the interpretations of the contractor, by the EPA (Goldstein, 1990:31). Another example occurred in October of 1989. The Office of Defense Waste and Transportation Management requested additional funds for a services contract with the BDM Corporation. The justification for this $3.6 million contract addition was that disapproval would have a major impact on the successful continued operation of the Department of Energy. In this case, a government agency was held captive by one of its contractors (Goldstein, 1989:34). In other words, the contractor was in a position of monopoly power relative to the government. "Our government has contracted out so many of its functions that it no longer has the capability to perform them itself. We are losing control" (Kuttner, 1986:14).

A fourth qualitative disadvantage of privatization is commonly known as conflict of interest (Goldstein, 1990:30). There are many documented cases of contractors being hired to assess the performance of another division of their own

company. For example, firms engaged in the cleanup of hazardous waste under contract to the EPA were simultaneously advising the companies that were responsible for the dumping in the first place (Goldstein, 1990:31).

A final qualitative disadvantage of privatization is that many fields of expertise require a tremendous breadth of knowledge and exposure. For example, expertise in the force structure planning requires a great deal of knowledge concerning threat analysis, force availability, force capability, and planned resource allocations. These fields of expertise are diverse, and require a great deal of time to master. The consultant may not have the breadth of expertise comparable to the government employee (Goldstein, 1990:32).

In addition to the qualitative issues mentioned above, opponents of privatization argue against it on a cost basis. This increased cost argument takes three forms. The first is that increased dependence on the contractor, combined with the loss of expertise, will lead to increased long term costs. The second is that competition does not really exist among consulting firms soliciting government business. The third is that a lack of government contract management expertise leads to fraud, waste, and abuse.

Dependence on a contractor, in the long term, may have the effect of increasing costs. As the contractor gains monopoly power relative to the government, it will become impossible to obtain necessary services at the lowest

possible cost. The contractor will begin to respond like a true monopolist, and the cost to the government will increase.

Proponents of privatization tout the virtues of competition and low cost when supporting their position. However, since 1980, some agencies, including the State and Defense departments, have assigned thousands of personal service contracts to specific individuals and corporations, with little or no competition. Many of the recipients of these contracts are organizations manned by former agency officials. The result is a small number of firms which become technical monopolists. Thus, the pure competition model does not represent the government consulting environment (Goldstein, 1990:30)

Even when limited competition exists, agencies are not necessarily getting the lowest cost service or product. Firms which do produce in the lowest cost manner will maximize profits, but there is no mechanism which insures the government will pay the lowest possible price. In addition, the contracting budget for different agencies has grown much faster than have the internal resources devoted to letting contracts and overseeing their performance. As a result, the General Accounting Office (GAO) has criticized agencies for making poor and often illegal contract decisions, and for keeping inadequate control over contractor's work. "Poor oversight has led to dozens of

cases where agencies overpay contracts and award unjustified contracts to firms" (Goldstein, 1990:31).

Many of these companies take advantage of the agency's lack of oversight, and engage in fraud, waste, and abuse. If services are contracted out, and the above mentioned concerns of dependence and loss of expertise become reality, the contractor is now in a position of monopoly power relative to the government. Not only does the government agency lose control of the decision making process, it loses negotiating power in determining the cost of the service (Goldstein, 1990:33). For example, much of NASA's work has long been performed by contractors. Nearly 80% of the NASA budget goes to private companies. A recent NASA inspector general report stated that approximately 33% of subcontracts were overpriced. Nearly 12% of contracts had a profit margin exceeding 100 percent and a few others had profit margins reaching 300 percent (Goldstein, 1990:36).

Summary

The debate over the pros and cons of privatization continues. Ideally, the private sector is more efficient than the public sector, and government ought to stay out of as many realms of operation as possible (Kuttner, 1986:14). However, closer inspection reveals the situation to be less than ideal.

> In theory, contracting out government services brings to the public realm all the virtues of the private market - flexibility, innovation, and competition. In practice, however, contracting out government begs the ancient political question: Who will watch the watchers? (Kuttner, 1986:14)

There is evidence that when too many services are contracted out, there are not enough public officials, and too little public sector *esprit de corps* to keep the process honest. Beyond a certain point, government by contract couples the inefficiencies of the public sector with the worst aspects of the private sector (Hanrahan, 1983:365).

The recent Pentagon freeze on hiring in many civilian personnel categories, proposed cuts in the military ranks, and decreasing budget authority will probably accelerate DoD's dependence on private firms. Even though the budget process continues to squeeze personnel accounts, the governments work still needs to get done (Goldstein, 1990:57).

Answering the questions associated with privatization on a Federal Government level would be impossible. The purpose of this thesis is to examine the costs and benefits of performing the same function at two different locations (AEDC and NAPC), one which uses primarily a contractor workforce, and the second which uses an all government workforce.

III. Methodology

Chapter Overview

This chapter describes the procedures used to answer the investigative questions presented in Chapter I. Data collection included an extensive search of the literature, review of historical cost and personnel data, and numerous personal and telephone interviews. This chapter describes the population from which data were collected, how the data were analyzed, and the measures that were taken to ensure reliability and validity.

Research Approach

Data were gathered and analyzed to specifically address each of the two investigative questions. Each question is restated below, followed by a definition of its intent, and a description of individuals and organizations contacted.

Investigative Question One

What are the results of a cost comparison of the use of contracted labor at AEDC *vs* the use of in-house labor at NAPC?

The intent of this question is to determine what, if any, are the differences between the overall cost of contracting the labor force to provide ground test services *versus* the alternative of doing the work with in-house employees. The goal was to (1) determine if any differences exist, (2) quantify the cost difference, including all joint

costs, and (3) determine the reasons for the differences. The source of data included historical costs of contracted operations at AEDC, historical labor costs of NAPC, as well as demographic information on each workforce.

Investigative Question Two

What are the benefits and drawbacks of using contracted labor resources at AEDC, and how do they compare to those associated with using in-house labor at NAPC?

Potential benefits are a function of the number of errors resulting in re-accomplishment of particular tests, the flexibility in manning to meet required workload, the level of specialization and expertise of the labor force, and the existence and extent of innovation. Potential drawbacks are a function of management control, dependence on the private sector, potential for conflicts of interest, and the timeliness of responses to customer requests.

Interviews were conducted with members of the AEDC and NAPC staffs to assess the benefit differences between the facilities. The task was to determine if these differences are attributable to contractor *vs* government manning. An effort was made to identify specific examples which could support a subjective evaluation.

Data Analysis

The costs of AEDC are determined using a total cost approach, which includes both direct and indirect costs. Actual historical cost data is readily available. Using

historical labor costs, total labor costs at NAPC are estimated using a factor to increase actual wages and salaries to reflect absence and retirement benefits. These costs are added to all other costs to obtain total cost. Resulting total costs, in 1990 dollars, are then analyzed. Regression analysis is used to control for variations in workload between AEDC and NAPC.

The qualitative issues raised by Investigative Question 2 are assessed through the use of personal and telephone interviews and discussions.

The questions were open ended, not limited to yes or no responses, in order to facilitate discussion. The interviews began with a brief description of the study, and the possible uses of the results.

The first part of the interviews with government personnel concentrates on the qualitative advantages of using contracted labor. Questions are designed to determine if the number or errors causing re-accomplishment of particular tests were significantly different at NAPC and AEDC. In addition, questions addressed the level of expertise and specialization of labor the contractor arrangement provides, and the flexibility (in terms manning to meet requirements) this labor force produces. Finally, questions were asked concerning the evidence of historical contractor innovation.

The next portion of the discussions with government personnel concerns qualitative advantages of using in-house

labor. Questions are designed to determine if the use of in-house labor vs contractor labor enhances management control.

The final portion of the discussions with government personnel addresses the potential for increased dependence on certain contractors, conflicts of interest, and the lack of responsiveness to customer needs on the part of the in-house labor force.

The first part of the interviews and discussions with contractor personnel addresses the contractor policies dealing with innovation. In addition, questions address the issue of manning flexibility and expertise.

Finally, questions address the current policies and procedures dealing with management control and accountability (of the Air Force at AEDC).

Throughout the process, additional information was required. This information was retrieved via telephone interviews. This information supplemented data gathered via personal interviews.

The use of the techniques cited above should enhance the reliability and validity of the information obtained, serving to maximize data integrity.

IV. Presentation of Results

Chapter Overview

This chapter presents a discussion of the findings related to the investigative questions presented in Chapter I. Data were gathered and analyzed to specifically answer each of the investigative questions. Each of the two investigative questions is repeated below, followed by a discussion of the results pertinent to that specific question.

Investigative Question One

What are the results of a cost comparison of the use of contracted labor resources at AEDC vs the use of in-house labor at NAPC?

To answer this question, the total current AEDC contract labor costs must be determined, and the variables influencing those costs investigated. The results will then be compared to the cost of using a government employee workforce at NAPC.

Determining Actual Contract Cost.

The first step was to determine the actual cost of the contracted labor force currently in place at AEDC. Using accounting data for the past thirty-six years (FY 54 - FY 90), total contractor labor dollars for aerodynamic testing, engine testing and base support ranged from $ 22.6 million to $ 198.3 million, in then-year dollars (Sutton, 1991).

There are two main reasons for the large variances. First, the contracts at AEDC are based on a level of required annual effort. Each year, anticipated test workload is defined by the Air Force, and manning required to meet this level of effort is determined. This manning level is then negotiated with the contractor. As a result of uneven workload and scheduling, manning, and the associated labor dollars, are not held constant from year to year. The table on the following page, Table 1, and the following graph, Figure 1, detail the historical workload for AEDC. Workload is segregated into two components, engine testing hours and aerodynamic testing hours. Engine testing consists of tests performed on turbine and rocket motors. Aerodynamic testing consists of wind tunnel and space environmental tests. Early workload for AEDC is relatively low due to initial start-up of facilities. Workload, and its components are measured in customer "Air-On-Hours." Air-On-Hours (AOH) is a measure of the number of clock hours a test unit is operating with the test article inside. It is the time in which air is actually flowing through the test chamber. The measure only accounts for actual test time, and ignores installation, and removal of the test article. Historical data for the same period indicates that actual manning for AEDC has ranged from 1,854 to 4,339 employees. In addition, inflation, in the form of wage and salary increases, and increases in fringe benefit costs, is present in the labor dollar figures (Pickering, 1991).

TABLE 1

WORKLOAD COMPOSITION: AEDC

	AIR-ON-HOURS (AOH)		
FISCAL YEAR	ENG HRS	AEROHRS	TOTALHRS
54	7	14	21
55	194	284	478
56	610	499	1,108
57	951	352	1,304
58	1,028	400	1,427
59	1,224	487	1,711
60	1,290	554	1,843
61	706	1,059	1,764
62	1,177	1,438	2,615
63	1,131	1,692	2,822
64	1,943	1,195	3,138
65	2,150	1,151	3,301
66	1,383	1,690	3,073
67	1,319	1,713	3,032
68	1,246	1,791	3,036
69	1,063	1,464	2,526
70	927	1,133	2,060
71	761	825	1,586
72	769	800	1,569
73	1,456	971	2,426
74	1,410	1,154	2,564
75	1,068	1,306	2,374
76	1,171	1,016	2,187
77	1,149	1,104	2,253
78	951	1,538	2,489
79	1,852	768	2,620
80	1,158	1,415	2,574
81	974	1,190	2,164
82	1,004	1,293	2,297
83	1,616	828	2,444
84	1,505	1,166	2,672
85	1,510	1,179	2,689
86	1,191	1,460	2,651
87	1,388	1,397	2,785
88	1,429	1,158	2,587
89	1,139	1,563	2,702
90	1,507	878	2,385
AVERAGE	1,204	1,109	2,313

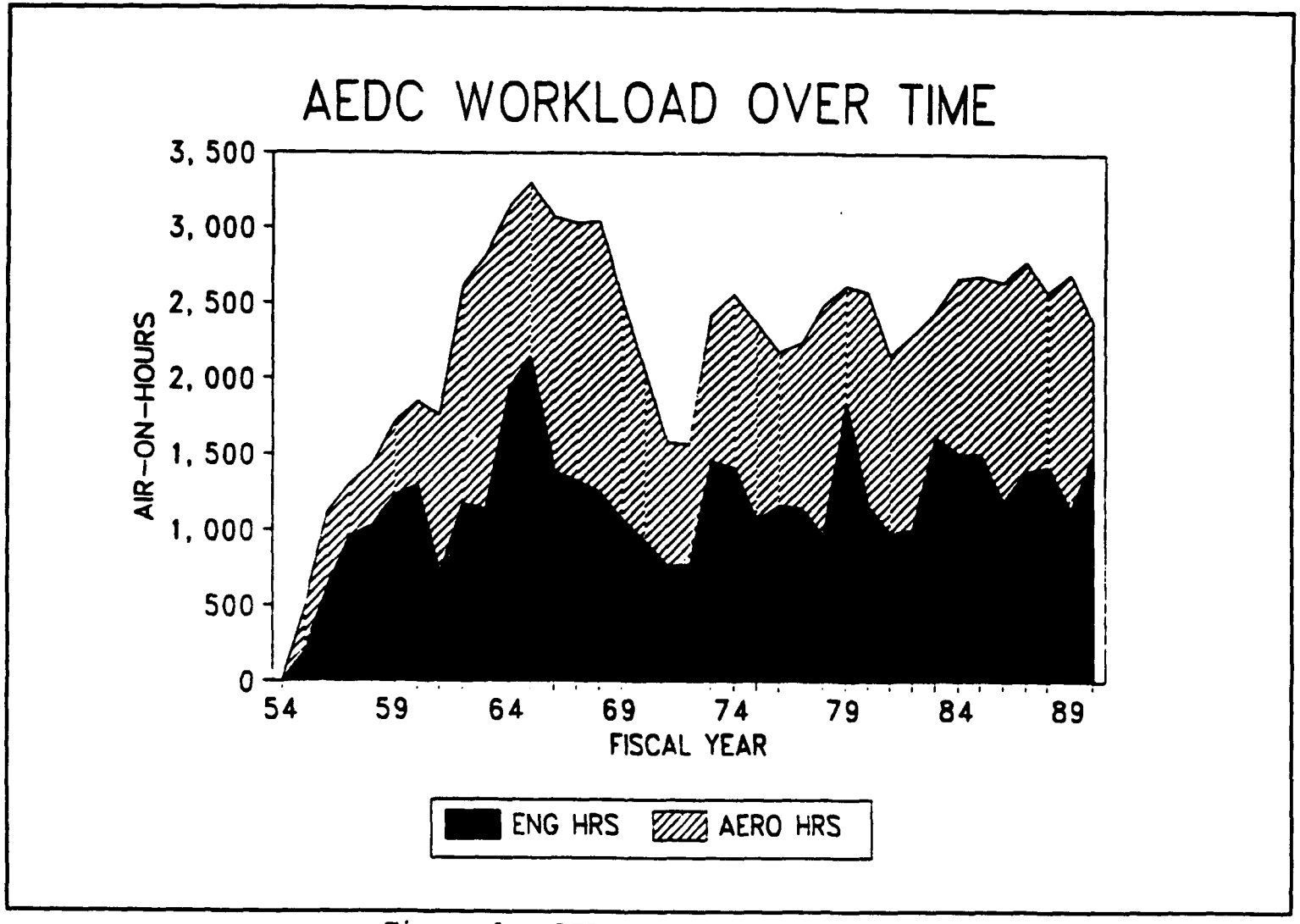

Figure 1. AEDC WORKLOAD OVER TIME

Because of their instability, simply reviewing the total labor dollar amounts would not be an acceptable means of evaluating the contractor labor cost for a given year.

To remedy the two aforementioned problems associated with contract labor costs, a two-step process is indicated. The first step adjusts all annual costs, converting them into constant, FY 1990 dollars. All AEDC contract costs are paid with 3600 appropriation - research, development, test and evaluation - monies (Milhiser, 1991). Using FY 90 as a base year, all annual costs are adjusted into constant dollars, using the Air Force directed inflation indices for 3600 appropriations. Appendix A lists all AEDC costs, in FY 90 dollars. To adjust for the effect of various manning levels on total labor costs, a series of regression analysis is performed, using test workload as the independent variable, and cost data (adjusted into FY 90 dollars), as the dependent variable. Total costs can be segregated into five component parts: (1) labor costs (including associated fringe benefit costs), (2) utilities costs, (3) materials costs, (4) other costs (travel, consultants, etc.), and (5) award fee (profit). Before performing the regression analyses, a correlation analysis is performed on all variables. The table on the following page, Table 2, summarizes the correlation matrix for the AEDC data. The matrix suggests two main findings. First, each of the cost elements, except award fee, are strongly, positively, correlated with each other. Second, total workload hours

TABLE 2

CORRELATION MATRIX: AEDC COST AND WORKLOAD DATA

Correlation Analysis

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 37

	LABOR	UTIL	MAT	OTHER	FEE	TOTCST	AERO HRS	ENGHRS	TOTHRS
LABOR	1.000	0.832	0.839	0.728	0.106	0.986	0.696	0.828	0.914
	0.0	0.001	0.001	0.001	0.530	0.001	0.001	0.001	0.001
UTIL	0.832	1.000	0.918	0.895	0.144	0.910	0.572	0.645	0.729
	0.001	0.0	0.001	0.001	0.393	0.001	0.002	0.001	0.001
MAT	0.839	0.918	1.000	0.889	0.061	0.903	0.555	0.642	0.717
	0.001	0.001	0.0	0.001	0.717	0.001	0.004	0.001	0.001
OTHER	0.728	0.895	0.889	1.000	0.163	0.811	0.486	0.520	0.602
	0.001	0.001	0.001	0.0	0.333	0.001	0.002	0.009	0.001
FEE	0.106	0.144	0.061	0.163	1.000	0.117	-0.022	0.027	0.004
	0.530	0.393	0.717	0.333	0.0	0.490	0.896	0.869	0.980
TOTCST	0.986	0.910	0.903	0.811	0.117	1.000	0.683	0.801	0.889
	0.001	0.001	0.001	0.001	0.490	0.0	0.001	0.001	0.001
AERO	0.696	0.572	0.555	0.486	-0.022	0.683	1.000	0.397	0.827
HRS	0.001	0.002	0.004	0.002	0.896	0.001	0.0	0.014	0.001
ENGHRS	0.828	0.645	0.642	0.520	0.027	0.801	0.397	1.000	0.844
	0.001	0.001	0.001	0.009	0.869	0.001	0.014	0.0	0.001
TOTHRS	0.914	0.729	0.717	0.602	0.004	0.889	0.827	0.844	1.000
	0.001	0.001	0.001	0.001	0.980	0.001	0.001	0.001	0.0

are strongly correlated with total costs, labor costs, utilities costs, and materials costs. To further investigate possible causal relationships, regression analyses are performed. The first of these investigates the relationship between total workload hours and total cost. This single independent variable model produced the following linear equation:

Total Cost = 115,821,657 + 52,888 (Air-On-Hours) (1)

Table 3 details the statistics of the regression model.

TABLE 3

REGRESSION RESULTS: AEDC COST vs TOTAL WORKLOAD

N 37		R^2 .7919	
Dependent Variable: Total Cost			
Independent Variable	Coefficient	T-value	Prob>T
Total Air-On-Hours	53,532	11.542	0.0001

The model is statistically significant at greater than a 1% level . The coefficient of determination, called r-squared, is .7919. This means that of all the variability in total cost, 79.19% can be explained by the variability in total air-on-hours. Figure 2, represents the linear relationship discovered between total cost, and total air-on-hours. Because total costs and total workload are so strongly related, each of the components of total costs is

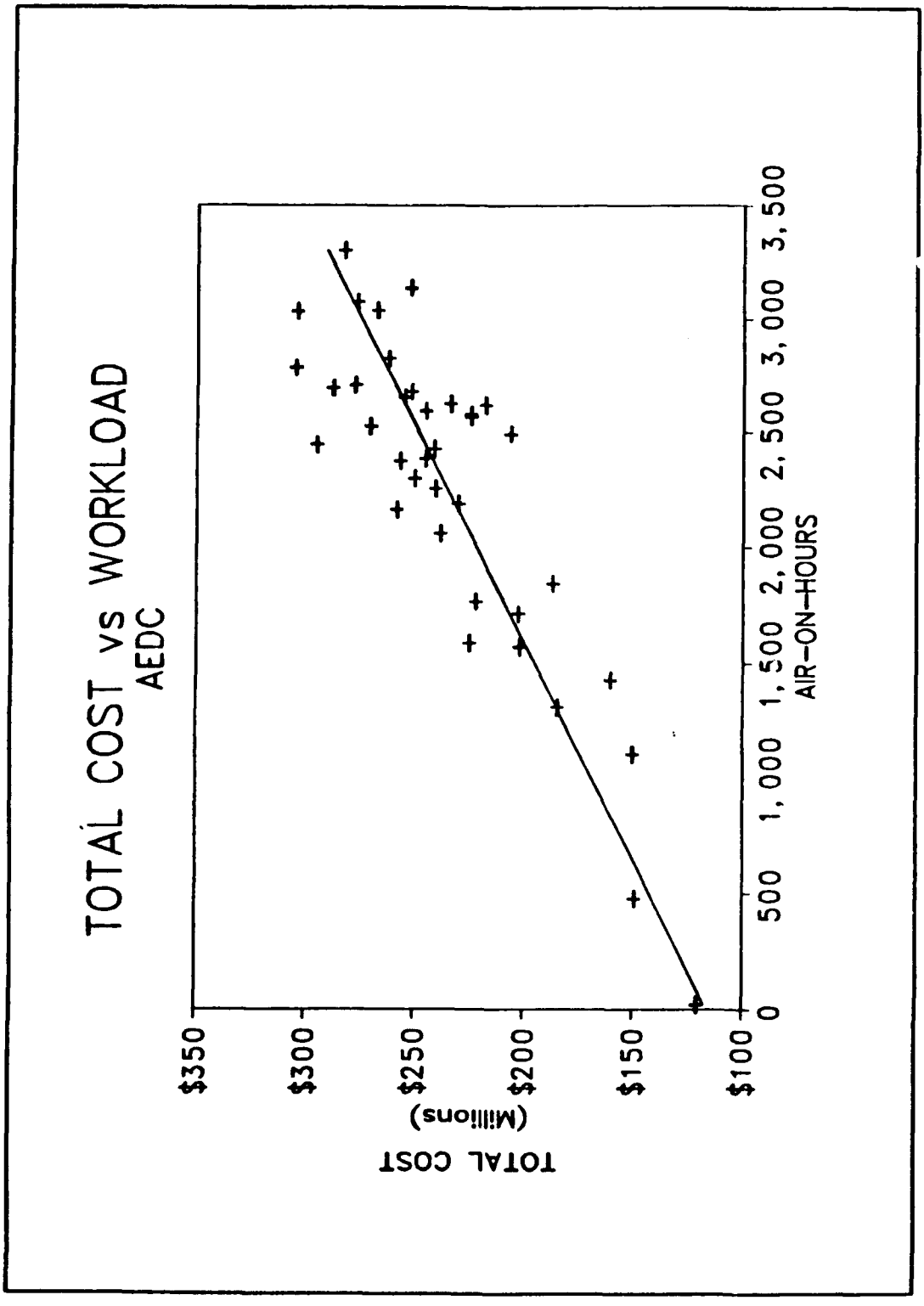

Figure 2. AEDC TOTAL COST vs WORKLOAD

regressed against total workload. The following table,Table 4 summarizes the results.

TABLE 4

REGRESSION RESULTS: COST COMPONENTS vs TOTAL WORKLOAD

N = 37

Independent Variable

Total Air-On-Hours

Dependent Variable	r^2	Coefficient	T-value	Prob>T
Labor Cost	.8356	40,087	13.337	0.0001
Utilities Cost	.5319	9,564	6.306	0.0001
Materials Cost	.5152	3,112	6.099	0.0001
Other Cost	.3635	768	4.471	0.0001
Award Fee	.0000	19.30E-7	0.025	0.9801

Labor costs average 75.2% of total costs, utilities average 17.4%, materials, 5.8%, other costs, 1.5%, and award fee, less than 0.1%. These results indicate that the relationship between total workload and labor cost is very strong. Because labor costs and workload are so strongly correlated, there should be some correlation between workload and manning. To test this hypothesis, manning is regressed against total workload. The single independent variable model produced the following linear equation:

Total Manning = 1,699 + .8018 (Air-On-Hours) (2)

Table 5 details the statistics of the regression model.

TABLE 5

REGRESSION RESULTS: AEDC MANNING vs TOTAL WORKLOAD

N	37		
R^2	.8483		
Dependent Variable:	Total Manning		
Intercept	1,699		
Independent Variable	Coefficient	T-value	Prob>T
Total Air-On-Hours	.8018	13.991	0.0001

The model is statistically significant at greater than a 1% level. The coefficient of determination, is .8483. Figure 3, represents the linear relationship discovered between total cost, and total air-on-hours. The implication of the above is that AEDC workload is an excellent predictor of manning, and therefore, labor costs, and that labor costs heavily influence total costs.

Determining Equivalent Government Labor Costs.

The Naval Air Propulsion Center (NAPC) is a facility which is very similar to AEDC in almost all respects. The facilities share the same mission, are approximately the same age, and have basically the same capabilities. A review of historical record concerning test workload reveals listings of customers, and a level of workload, which are almost identical. All pre-1976 data for NAPC was eliminated from the sample because the pre-1976 data represented a

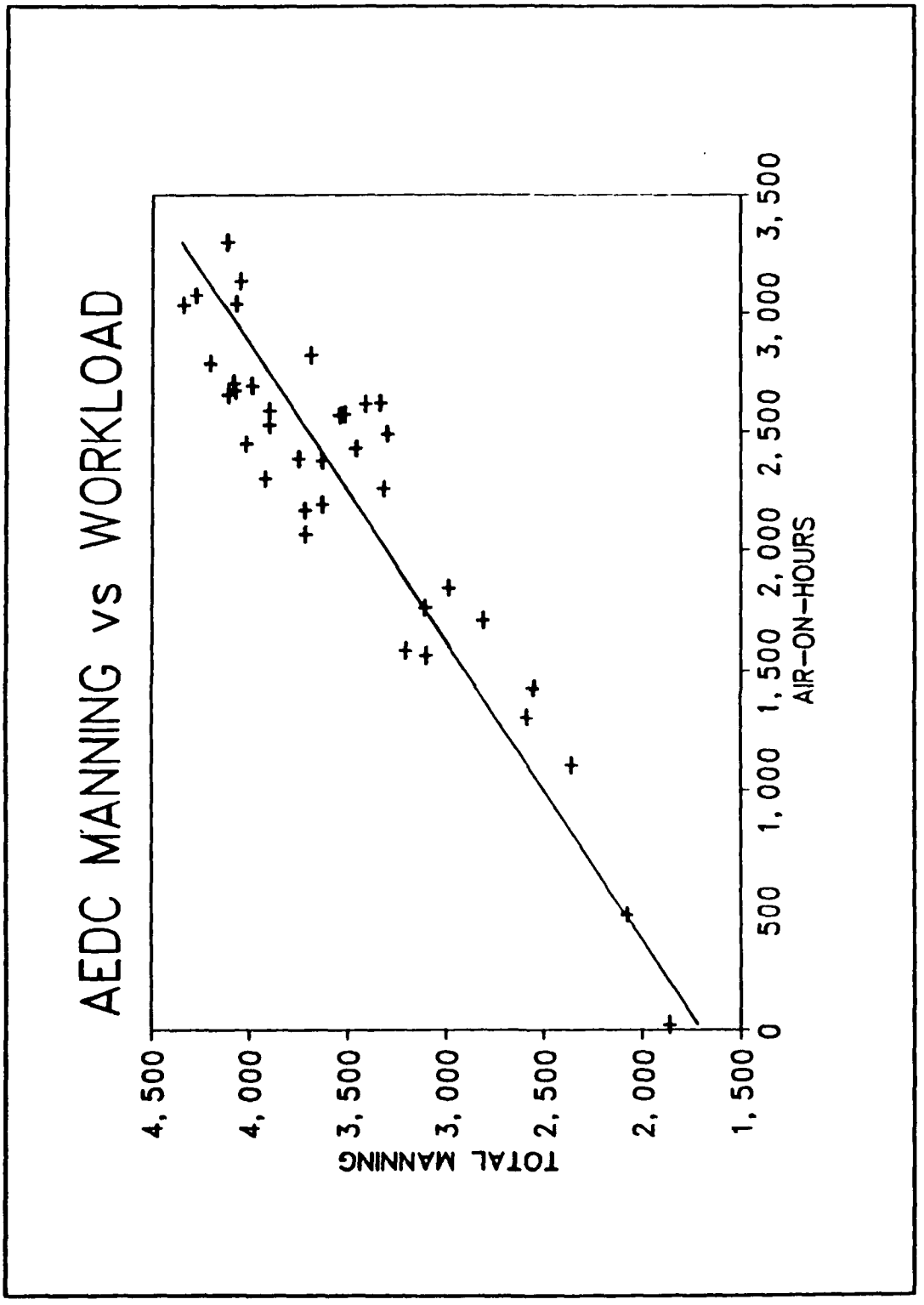

Figure 3. AEDC MANNING vs WORKLOAD

description of a facility that no longer exists. Table 6, and the following graph, Figure 4, provide a detailed description of the level of workload for NAPC, measured in terms of customer air-on-hours. The level of the individual components of workload, as well as the average for the sample, are similar to the figures presented for AEDC.

TABLE 6

WORKLOAD COMPOSITION: NAPC

AIR-ON-HOURS (AOH)

FISCAL YEAR	ENG HRS	AEROHRS	TOTALHRS
76	1,255	1,027	2,281
77	1,331	917	2,248
78	1,308	1,207	2,515
79	1,366	1,225	2,591
80	1,501	1,123	2,624
81	1,094	1,051	2,145
82	1,138	1,233	2,371
83	1,166	1,268	2,434
84	1,295	1,403	2,697
85	1,326	1,274	2,600
86	1,428	1,168	2,596
87	1,213	1,314	2,527
88	1,175	1,324	2,499
89	1,357	1,252	2,609
90	1,379	1,222	2,601
AVERAGE	1,380	1,286	2,666

Other than the fact that one facility is a Naval facility, and one belongs to the Air Force, the key difference between the two is that NAPC uses civil service employees as its only workforce, while AEDC uses operating

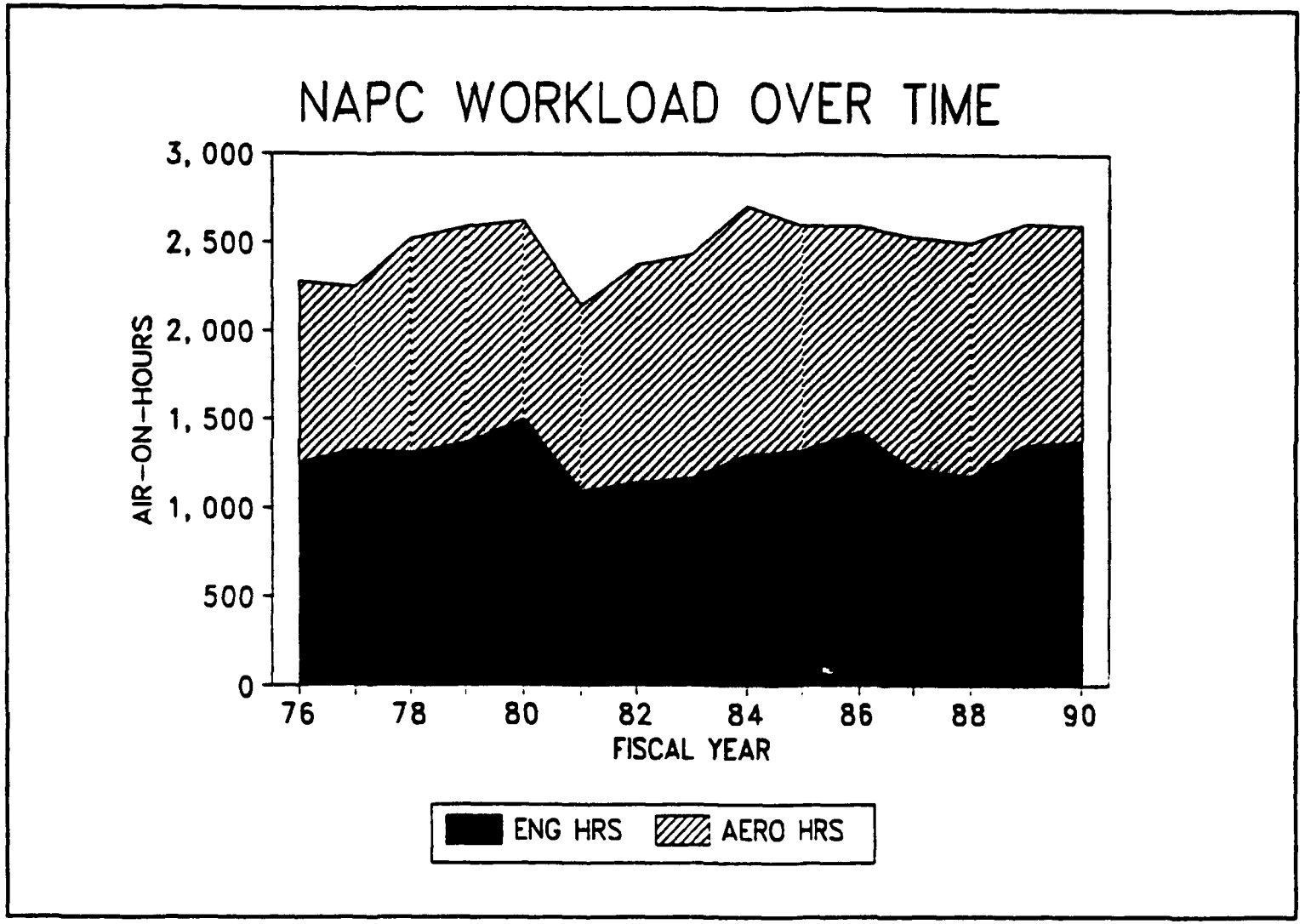

Figure 4. NAPC WORKLOAD OVER TIME

contractors as its primary workforce. Because it has only government employees, the NAPC organizational structure is different from AEDC. Propulsion test experts from AEDC have visited NAPC on many occasions, and in return, NAPC experts have visited AEDC. Both sets of experts agree that the organizational structure and manning approach are the only primary differences between the two test centers (Austin, 1991). Accordingly, for the purpose of this analysis, NAPC labor costs are considered to be a good model with which to compare AEDC labor costs.

The total labor hours and dollars at NAPC have not varied in the same way as those at AEDC in the past. Because government workers are not employed subject to a level of effort requirement, the level of manning has remained basically unchanged through time (Austin, 1991). However, inflation has affected the total labor costs in much the same way as it altered the AEDC contract labor costs. After adjusting the total NAPC labor cost by the same Air Force inflation indices (for 3600 appropriations), constant, FY 90 labor dollars could be estimated. However, the labor costs are not yet comparable to AEDC labor costs.

While the AEDC labor costs included all variable compensation costs (fringe benefit costs), the NAPC rate does not (Austin, 1991). It is simply the amount paid for wages and salaries. According to OSD/FMAMC, all civil service labor costs must be adjusted in consideration of absence costs (annual leave, holidays, sick leave, etc.) and

retirement benefits. To derive total labor costs, paid compensation must be increased by an adjustment factor of 1.2955. Applying this factor to the NAPC labor costs adjusts them, and portrays a total cost of labor estimate. This adjusted government labor costs, and associated total costs are now comparable to the AEDC total costs. Appendix B details the constant, FY 90 costs for NAPC.

The procedure used for AEDC data is repeated using the NAPC data. Costs categories are identical, except for the award fee category. Table 7 summarizes the correlation matrix for all the variables for the NAPC data. As before, all the cost components are strongly, positively correlated. However, unlike the AEDC results, none of the cost components are strongly correlated with total workload. To further investigate possible causal relationships, regression analyses are performed. The first of these investigates the relationship between total workload hours and total cost. This single independent variable model produced the following linear equation:

Total Cost = 177,713,035 + 29,774 (Air-On-Hours) (3)

Table 8 details the statistics of the regression model. The model is statistically insignificant. The coefficient of determination, is .0893. This means that of all the variability in total cost, only 8.93% can be explained by the variability in total air-on-hours. Figure 5 represents the linear relationship discovered between total cost, and

TABLE 7

CORRELATION MATRIX: NAPC COST AND WORKLOAD DATA

Correlation Analysis

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 37

	LABOR	UTIL	MAT	OTHER	TOTCST	AERO HRS	ENGHRS	TOTHRS
LABOR	1.000	0.795	0.786	0.800	0.843	0.123	-0.048	0.049
	0.0	0.004	0.005	0.003	0.001	0.662	0.864	0.861
UTIL	0.795	1.000	0.983	0.976	0.995	0.392	0.075	0.338
	0.004	0.0	0.001	0.001	0.001	0.147	0.788	0.217
MAT	0.786	0.983	1.000	0.969	0.985	0.431	0.002	0.308
	0.005	0.001	0.0	0.001	0.001	0.108	0.992	0.263
OTHER	0.800	0.976	0.969	1.000	0.980	0.320	0.048	0.266
	0.003	0.001	0.001	0.0	0.001	0.243	0.863	0.337
TOTCST	0.843	0.995	0.985	0.980	1.000	0.369	0.046	0.298
	0.001	0.001	0.001	0.001	0.0	0.175	0.868	0.279
AERO HRS	0.122	0.392	0.431	0.320	0.369	1.000	-0.110	0.623
	0.662	0.147	0.108	0.243	0.175	0.0	0.694	0.013
ENGHRS	-0.048	0.075	0.002	0.048	0.046	-0.110	1.000	0.708
	0.864	0.788	0.992	0.863	0.868	0.694	0.0	0.003
TOTHRS	0.049	0.338	0.308	0.266	0.298	0.623	0.708	1.000
	0.860	0.217	0.263	0.337	0.279	0.013	0.003	0.0

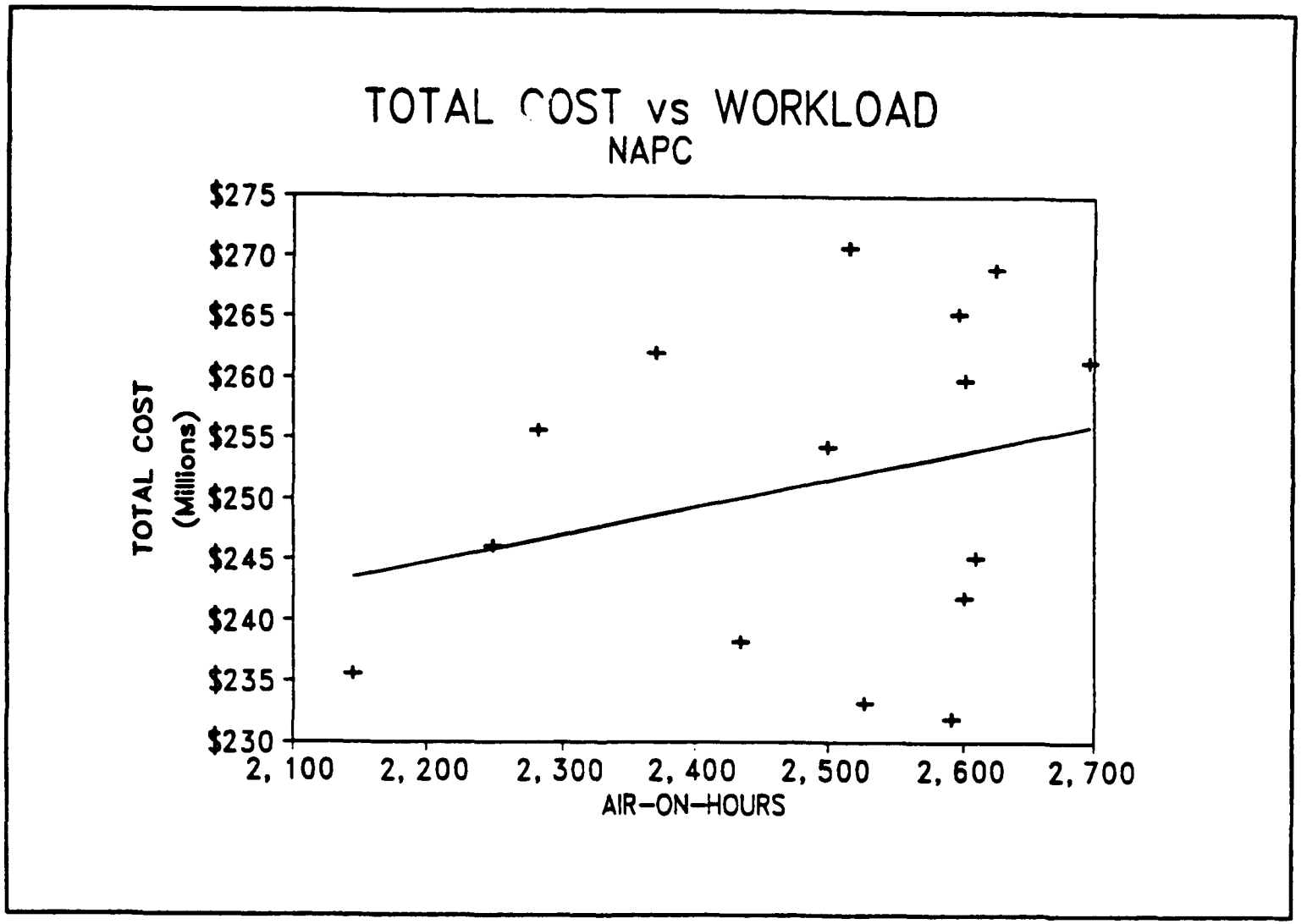

Figure 5. NAPC TOTAL COST vs WORKLOAD

TABLE 8

REGRESSION RESULTS: NAPC COST vs TOTAL WORKLOAD

N 15			
R^2 .0893			
Dependent Variable: Total Cost			
Independent Variable	Coefficient	T-value	Prob>T
Total Air-On-Hours	29,774	1.129	0.2792

total air-on-hours. Repeating the procedure used previously for AEDC data, each of the components of total costs is regressed against total workload. Table 9 summarizes the results.

TABLE 9

REGRESSION RESULTS: COST COMPONENTS vs TOTAL WORKLOAD

N = 15		Independent Variable		
		Total Air-On-Hours		
Dependent Variable	r^2	Coefficient	T-value	Prob>T
Labor Cost	.0024	669	0.179	0.8609
Utilities Cost	.1147	22,083	1.298	0.2170
Materials Cost	.0950	5,315	1.168	0.2638
Other Cost	.0708	1,706	0.996	0.3376

NAPC labor costs average 74.9% of total costs, utilities average 17.6%, materials, 6.0%, and other costs, 1.5%. These figures are not significantly different than the AEDC percentages. However, these results indicate that the relationship between total workload and labor costs is not very strong. Unlike AEDC, NAPC workload appears not to be a strong predictor of labor cost or total cost. A further indication of the lack of a relationship between workload and labor costs surfaces when the relationship between manning and workload is investigated. The single independent variable model produced the following linear equation:

Total Manning = 3,653 - .0011 (Air-On-Hours) (4)

Table 10 details the statistics of the regression model.

TABLE 10

REGRESSION RESULTS: NAPC MANNING vs TOTAL WORKLOAD

N 15		R^2 .0009	
Dependent Variable: Total Manning			
Intercept 3,653			
Independent Variable	Coefficient	T-value	Prob>T
Total Air-On-Hours	-0 .0011	0.106	0.9174

The coefficient of total workload is approximately zero, and is insignificant at the 5% level. The coefficient of

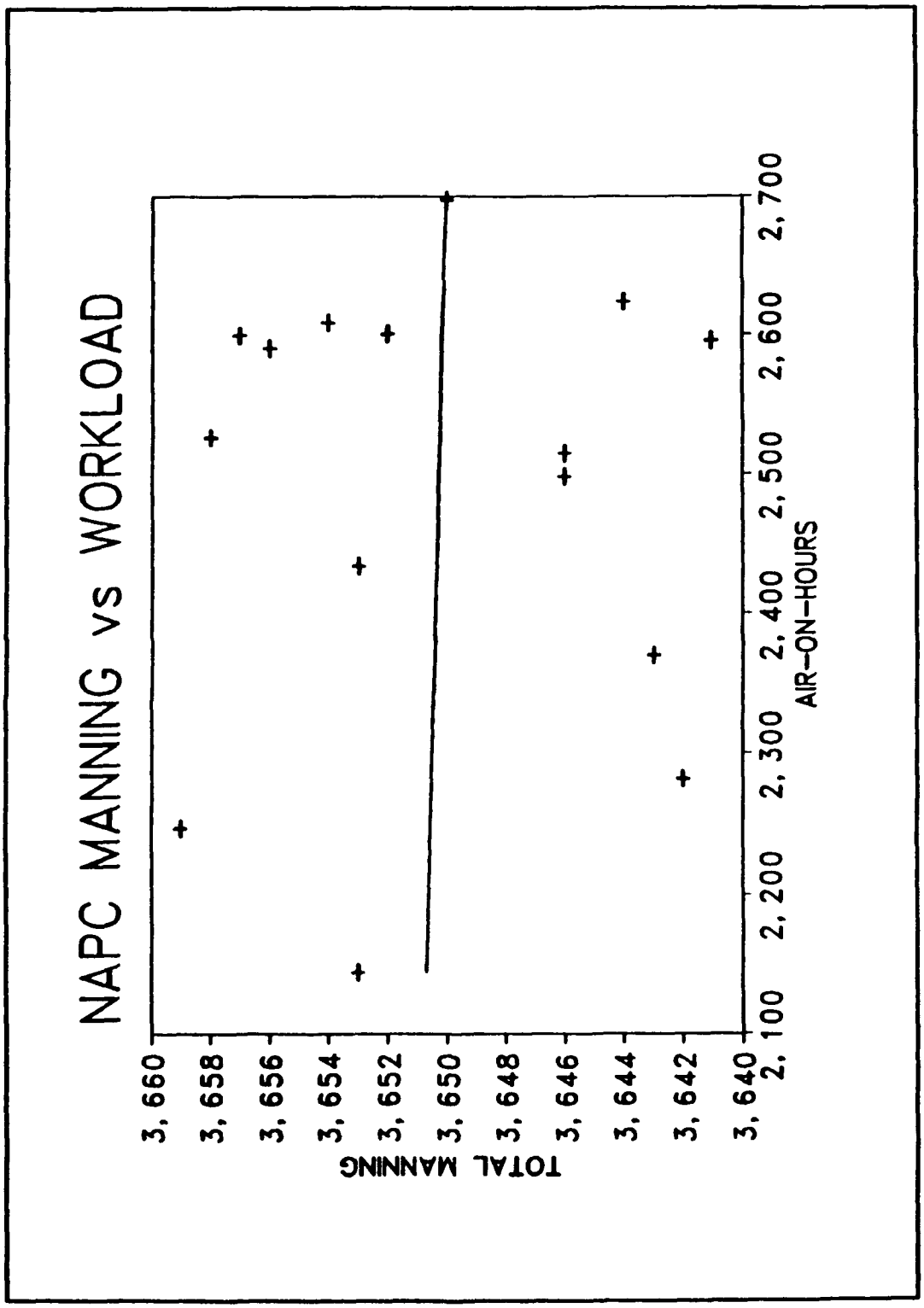

Figure 6. NAPC MANNING vs WORKLOAD

determination, is .0009. Figure 6 represents the linear relationship, or lack thereof, discovered between total manning, and total air-on-hours. The result of these regressions show that NAPC workload fails to explain total cost, any of the cost components, and facility manning. The apparent differences between the influences on cost can be statistically tested.

Cost Comparisons.

All total costs estimates used in calculating AEDC regression coefficients included all contract specific costs such as award fee, and general and administrative expense. Even including these costs, there appears to be a relatively strong relationship between total cost, labor costs, manning, and workload at AEDC. However, there seems to be no such relationship between total cost, labor costs, manning, and workload levels at NAPC.

To test the hypothesis that the influence of workload on total cost, and its components, is different for the two installations, all cost and workload data were combined, and a regression analysis was performed, using indicator variables. The indicator variables allow the slope and intercept of the equation to change, when applied to AEDC costs. Table 11, details the statistics of the regression model. The overall equation is statistically significant at greater than a 1% level. The variable for the baseline, NAPC case, is also statistically significant at greater than a 1% level. The indicator variables are also significant.

TABLE 11

REGRESSION RESULTS: COMBINED DATASET, USING DUMMY VARIABLES

TOTAL COST vs WORKLOAD

N	52
R^2	.7666
Adj R^2	.7520
F-Value	52.549
Prob >F	0.0001

Dependent Variable: Total Manning

Independent Variable	Coefficient	T-value	Prob>T
Intercept Dummy	63,421,523	0.799	0.4282
Total Air-On-Hours	53,532	12.171	0.0001
Slope Dummy	-23,758	11.746	0.0594

F-Test on Indicator Variables

F-value	3.104	Prob>F:	.0893

The intercept change value is not significant at the 5% level, but the slope change is significant at nearly the 5% level. The combined F-test is a test of the hypothesis that both the intercept and slope changes, taken both separately and in combination, are equal to zero. The statistics indicate that this hypothesis can be rejected at the 10% level of significance. These results indicate that the impact of workload on total cost is significantly different between AEDC and NAPC. Further analysis of the relationship

between workload and each of the cost components at each facility will help address the possibility of differences between the two facilities. Table 12 details the results of regression analysis of the combined dataset, using indicator variables.

TABLE 12

REGRESSION RESULTS: COST vs WORKLOAD

COMBINED DATASET, USING DUMMY VARIABLES

N 52

Dependent Variable: Total Cost

Cost Component	Indicator Variable	Prob>T
Labor Costs	Intercept Dummy	0.0359
	Slope Dummy	0.0402
Utilities Costs	Intercept Dummy	0.3596
	Slope Dummy	0.3389
Materials Costs	Intercept Dummy	0.6168
	Slope Dummy	0.5805
Other Costs	Intercept Dummy	0.5148
	Slope Dummy	0.5038

The only relationship between cost category and workload which appears to differ significantly between the two facilities is labor costs. Both the intercept change and slope change are significant at greater than a 5% level. Clearly, the relationship between workload and total cost differs between AEDC and NAPC. In addition, the

relationship between workload and labor costs differ between the two facilities as well.

Impact of Cost Differences.

To investigate the effect of these differences, another regression is performed. Workload has two distinct elements, aerodynamic testing hours, and turbine engine testing hours. Total AEDC costs are regressed against these two components of workload to control for any possible differences in cost impact. The multiple independent variable equation which results is:

$$\text{Total Cost} = 44{,}603\ (\text{Aerodynamic Hours}) + 61{,}866\ (\text{Turbine Hours}) \quad (5)$$

Table 13, details the statistics of the model.

TABLE 13

REGRESSION RESULTS: TOTAL COST vs WORKLOAD COMPONENTS

N	37
R^2	.8008
Adj R^2	.7891
F-Value	68.337
Prob >F	0.0001

Dependent Variable: Total Cost

Independent Variable	Coefficient	T-value	Prob>T
Aerodynamic Hours	44,603	5.188	0.0001
Turbine Hours	61,866	7.550	0.0001

The equation itself, and each of the variables are significant at greater than a 99.9% level of confidence. The coefficient of determination is .8008, and the adjusted r-squared is .7891. For predicting total cost, not only is total AEDC workload a good predictor, but the component parts, taken together, are good predictors also. This equation can be used to demonstrate the differences between the AEDC workload/total cost relationship, and that at NAPC.

Using the workload component data for NAPC, and the above AEDC equation, a predicted NAPC total cost is obtained. In addition, a 95% confidence interval is calculated. Table 14 summarizes these calculations. There are ten observations for which actual cost exceed predicted cost. Four of these ten are above the 95% confidence interval upper bound. There are only five observations for which actual costs are lower than predicted. One of these is below the 95% confidence interval lower bound. There is a significant cost impact as a result of the different total cost/workload relationships at AEDC and NAPC.

Investigative Question Two

What are the benefits and drawbacks of using contracted labor resources at AEDC, and how do they compare to those associated with using in-house labor at NAPC?

There are seven areas which require investigation to answer this question. These concern (1) the number of errors resulting in re-accomplishment of particular tests,

TABLE 14

NAPC ACTUAL COSTS vs PREDICTED

USING AEDC MULTIVARIATE EQUATION

PREDICTED COST	ACTUAL COST	UPPER 95% INTERVAL	LOWER 95% INTERVAL	
235,274,469	258,743,842	215,415,252	255,133,686	*
231,859,037	243,243,863	211,999,820	251,718,254	
248,774,308	275,552,487	228,915,091	268,633,525	*
252,474,870	230,109,791	232,615,653	272,334,087	*
252,185,943	272,326,243	232,326,726	272,045,160	*
229,578,170	231,084,957	209,718,953	249,437,387	
242,800,314	264,788,146	222,941,097	262,659,531	*
246,214,508	237,523,118	226,355,291	266,073,725	
260,320,205	266,673,334	240,460,988	280,179,422	
253,722,184	237,218,659	233,862,967	273,581,401	
251,713,894	265,776,462	231,854,677	271,573,111	
251,156,685	232,862,388	231,297,468	271,015,902	
250,080,431	254,783,124	230,221,214	269,939,648	
253,743,825	243,224,242	233,884,608	273,603,042	
252,869,111	263,551,670	233,009,894	272,728,328	

* OBSERVATION FALLS OUTSIDE THE 95% CONFIDENCE INTERVAL

(2) flexibility in manning to meet customer requirements, (3) the degree of specialization and expertise of the labor force, (4) innovation in the area of new test techniques, methodologies, and capabilities, (5) management control, (6) dependence on private contractors, and (7) potential for conflicts of interest.

Errors/Re-Accomplishment of Test Services.

A primary advantage of contracting for government services presented in the review of the literature was the contractors' ability to provide a more useful product, which

better met the needs of the government. To address this area, data were retrieved concerning AEDC policies and procedures enacted if work was not performed to standards set by the user (whether the user is the AEDC Air Force management, or a test customer).

There are three types of faulty work: the use of wrong procedures, simple errors or mistakes, and inaccuracies due to instrument or test cell failure. The end user, or recipient of the services, determines if services performed were faulty (Austin, 1991).

If the services were faulty due to the use of incorrect procedures, the contractor, while completely at fault, does not bear the entire financial burden of correcting the error. Current AEDC policy dictates that the service (usually a test) will be repeated in its entirety, at no charge to the customer. AEDC funds the additional test costs from internal Air Force monies. However, the contractor is penalized during the award fee determination process. The error will be highlighted, and a significant portion of the potential award fee will be rescinded (Sutton, 1991). As previously mentioned, each individual employee shares in the award fee granted to the contractor. Therefore, each individual employee has a financial incentive to minimize or eliminate faulty work.

If the services were faulty due to a mistake or error, the contractor, while at fault, will not penalized as severely. Again, current AEDC policy dictates that the

service will be repeated in its entirety, at no charge to the customer. AEDC will fund the additional test costs from internal Air Force monies. In this case, the contractor is penalized only a minimal amount during the award fee determination process (Sutton, 1991).

If the services were faulty due to instrument or test cell failure, the contractor is not deemed to be at fault, and bears no financial burden of correcting the error. Current AEDC policy dictates that the service will be repeated in its entirety, completely at AEDC (Air Force) expense (Sutton, 1991).

All DoD ground test facilities have similar policies concerning faulty work. For example, NAPC will repeat faulty services at no cost to the customer. However, government employees have no personal financial incentive to limit or eliminate the amount of faulty work (Austin, 1991).

Over the past five years, AEDC has experienced only one error, which required re-testing an article to meet customer needs. In this case, the error was due to equipment malfunction, and the contractor was not deemed to be at fault. During this same period, there were five instances of errors at NAPC which required re-testing an article to meet customer needs. Two of these were the results of errors on the part of personnel (Austin, 1991).

Flexibility.

Another advantage of contracting for government services presented in the review of the literature was the

contractors' flexibility in manning to meet requirements. Historical data indicated that manning has varied dramatically in the past at AEDC, while remaining relatively constant at NAPC.

As previously mentioned, though the contracts at AEDC cover a five year period, workload, and required manning are negotiated annually. In 1987 and 1989, fiscal year workload requirements required an increase in manning from that of the previous year (Austin, 1991). In each case, the additional manning necessary to meet test workload requirements was employed during the first two months of the fiscal year. In 1987, 31 additional employees were hired, and in 1989, 52 additional employees were hired (Sutton, 1991). Both of these increases are small, relative to the size of the workforce, but there is historical precedent for a much larger increase. In November of 1985, one of the AEDC rocket motor test cells was destroyed, when the test article detonated during a test. Over a two month period, the capability lost due to the destruction was determined to be vital to the success of the Peacekeeper ballistic missile program, and the decision was reached to rebuild the facility. The current operating contractor responsible for engine and motor testing at AEDC was chosen to chair the effort to rebuild the facility. The contractor increased manning by over 15% in a three week period to begin the design and reconstruction effort (Austin, 1991). In all of these examples, the key issue is that the contractor is not

subject to manning ceilings imposed on government organizations. As such, the contractor is free to increase manning, sometimes dramatically, in a short period of time to meet job requirements (Pickering, 1991).

The converse is also true. In 1986, 1988, and 1990, workload requirements were not at a sufficient level to maintain the workforce from the previous year. In 1986, and 1990, permanent (reductions in force) and temporary layoffs were used to reduce manning to the required level. In 1988, an early retirement program was used for the same purpose. The layoffs in 1986 and 1990 affected 72 and 50 employees respectively. The early retirement in 1988 affected 155 employees (Sutton, 1991). None of these actions occurred at no cost to the government. All costs associated with these reductions in the workforce were charged to the government as costs of the contract (Milhiser, 1991). These costs include severance, accrued vacation, early retirement incentives, etc. The central issue, however, is that in each case, the action to reduce the workforce occurred quickly (within two months of making the decision to reduce the workforce). It would be impossible for a government workforce to react in such a manner, given the complex administrative requirements associated with a reduction in force (Macchonie, 1991).

The flexibility in manning to meet work requirements does not come without a price. Because contractor employees are not true government employees, their positions are not

protected when budgets are reduced. Contractors at AEDC are solely dependent of the level of expected workload for their job security. At NAPC, all workers are government employees. As the defense budgets have decreased over the last five years, no positions have been eliminated at NAPC. The civil service employees jobs have been protected from the effects of budget reductions (Austin, 1991).

Because of these aforementioned reasons, one would expect that workload and the level of manning would be strongly correlated at AEDC, and not nearly so at NAPC. Tables 4 and 10, along with Figures 2 and 4, support this hypothesis.

Specialization and Expertise of the Workforce.

A third advantage of contracting for government services presented in the review of the literature was the contractors' increased level of specialization and expertise. To address this area, data were retrieved concerning employee qualifications (education level, and years of experience) and employee turnover.

Over the past five years, the mix of employees has remained basically constant (Sutton, 1991). There are three basic classes of employees the contractor uses. The first of these is craft personnel. These employees are carpenters, plumbers, machinists, etc. They are labor union workers, and are compensated on an hourly basis. This portion of the workforce comprises 32% of the contractor workforce. The average employee in this classification has

14 years experience at AEDC, and 17 years experience in their job specialty. Less than 10% of these employees have any formal education. However, all meet local labor union certification requirements. The second category is administrative and clerical personnel. These employees are administrative assistants, file clerks, and accounting technicians. These personnel are compensated on a salary basis, but are compensated for overtime work. This portion of the workforce comprises only 11% of the contractor workforce. The average employee in this classification has 9 years experience at AEDC, and 14 years experience in their job specialty. Over 50% of these employees have a bachelor's level degree. The third category of workers are the professional staff. These employees are the engineers, accountants, and managers. These personnel are compensated on a salary basis, and are not compensated for overtime. This classification of worker comprises the remaining 57% of the contractor workforce. The average employee in this classification has 22 years experience at AEDC, and 26 years experience in their job specialty. All of these personnel have a Bachelor's level degree. In addition, 25% of these employees have a Master's level degree. Of the total, 10% have their Doctorate (Pickering, 1991).

Information concerning the NAPC workforce qualifications and experience are used for comparison purposes. There are several key differences between the AEDC personnel, and their NAPC counterparts.

NAPC has approximately the same portion of its workforce in the three aforementioned job categories (Austin, 1991). For each job category, the average NAPC worker had fewer years of experience both at the specific facility, and in their chosen job specialty. However, these differences were relatively small. For craft labor, NAPC workers had 2 fewer years experience than their AEDC counterparts. For administrative and clerical labor, NAPC workers had 3 fewer years experience than their AEDC counterparts. Finally, for the professional staff, NAPC workers had 5 fewer years experience than their AEDC counterparts (Austin, 1991).

The education level of the craft employees and administrative and clerical employees were similar for AEDC and NAPC personnel. The key difference between the workforces of the two facilities concerned the education level of the average professional staff employee. At NAPC, only 75% of the professional staff had achieved a Bachelor's level degree. Less than 10% had achieved a Master's level degree, and less than 3% had achieved a Doctorate (Austin, 1991). The table on the following page, Table 15, summarizes the classification of workers, the percentage of the workforce each comprises, and the percentage of total labor dollars each classification contributes for AEDC and NAPC.

The impact of having qualified employees is mediated by the amount of employee turnover experienced by an

organization. An attrition rate is a measure of employee turnover. The historical attrition rate for the contractors at AEDC has ranged from 3.3% to 5.1% annually, ignoring the effects of forced reductions in force, layoffs, furloughs, and early retirements. The average rate for the last five

TABLE 15

PERSONNEL STRENGTH

AEDC

EMPLOYEE CATEGORY	% FORCE	% PAYROLL
CRAFT	32 %	27 %
ADMIN/CLERICAL	11 %	8 %
PROFESSIONAL	57%	65 %

NAPC

EMPLOYEE CATEGORY	% FORCE	% PAYROLL
CRAFT	35 %	30 %
ADMIN/CLERICAL	15 %	13 %
PROFESSIONAL	50%	57 %

years is 4.3%. At this rate, a complete workforce turnover would take over 23 years (Sparks, 1991).

The attrition rate for the government workforce at NAPC has been slightly smaller than that experienced at AEDC. The historical attrition rate for the government workforce has ranged from 2.6% to 4.2% annually. The average rate for the last five years is 3.6%. At this rate, a complete workforce turnover would take over 27 years (Austin, 1991).

Innovation.

A third advantage of contracting for government services presented in the review of the literature was the contractors' incentive to seek out new innovations. To address this area, data were retrieved concerning historical innovations originated by the contractor both during the contract period, and during the contract competition process.

The contracts at AEDC are the cost plus award fee type. A major area of evaluation and award fee determination is evidence of contractor management innovation. Thus, contractor management has a tremendous financial incentive to find and implement innovations. Accordingly, the contractor documents evidence of this innovation, and its effects during the award fee determination briefings. Current procedure requires that all claims be validated by Air Force officials. Over the last five years, these validated claims of management innovations have resulted in direct cost savings and indirect cost avoidance to AEDC and its customers of over $22 million, an average of $4.5 million annually (Sutton, 1991). There are many specific examples of these changes initiated by the contractor management team. In 1988, the contractor's management designed and implemented a new electronic timekeeping system, eliminating the need for timeclocks and timecards for hourly employees. The use of this new system saved more labor dollars in the first year of operation, than it cost

to design and install (Kimzey, 1991). The contractor developed a computerized project cost and schedule estimating system, which is based on historical data, and updated and validated annually. This new system allows management to assess the impact of workload changes on scheduling and manning almost instantaneously. In addition, annual workload requirements can be translated into manpower requirements in 5 to 10 fewer days than previously experienced, thus reducing time required for contract proposal development, and contract negotiations. Efficiencies experienced because of the advanced scheduling features have reduced the required manning for jet engine tests by 15% over the last five years, and manning for rocket motor tests by over 20% over the last five years (Austin, 1991). Nearly all of the documented innovations originated in other areas of the contractor's operation, and their application was imported to AEDC (Kimzey, 1991).

The contracts at AEDC are competed every five years. Because the contracts are cost plus award fee, the winning contractor is certain to make a profit (Pickering, 1991). Accordingly, competition for these contracts can be fierce. In FY 90, competition for the contracts for FY 91 - FY 95 was held. For the three efforts (propulsion testing, aerodynamics testing, and base support) a total of 19 firms submitted bids. Several of the firms, including the three incumbents, included innovative management concepts in their bids (Pickering, 1991). One such innovation, which was

subsequently adopted by all winning offerors was the shared award fee concept. Under this concept, all employees receive a small portion of the award fee granted to the contractor during award fee determination hearings. Each individual member of the labor force now has a financial incentive to increase productivity and performance (Sutton, 1991).

Government employees have fewer financial incentives linked directly to the pursuit of innovations. For example, no data exists for NAPC which documents innovations, and resulting cost savings or service improvements, which are tied directly to ongoing operations (McGowan, 1991).

Management Control.

A primary disadvantage of contracting for government services presented in the review of the literature was that the dependence on a contractor blurs the division of responsibility of the government agency. To address this area, data were retrieved concerning AEDC policies and procedures related to the definition of work requirements, the impact of changes to these requirements, and the identification of those responsible for directing and managing the contractors' efforts. These policies are then compared to those present at NAPC.

In theory, the AEDC process for work requirement definition, and division of responsibility is as follows. The definition of work requirements occurs in two phases, which match the rough division of types of work. Test

workload is divided into two distinct areas, activities, and projects. Activities are ongoing processes which have no discernable beginning or end. An example of an activity would be personnel services, accounting and financial management, public affair services, etc. These functions, and the specific jobs to be accomplished by each function, are described in great detail in the statement of work in the contract. The second work type is a project. Projects have a defined beginning and end. These are specific tests requested by AEDC customers (Austin, 1991). Near the end of a given fiscal year, the number and type of test projects anticipated for the next fiscal year are determined by AEDC Air Force officials. All specific test objectives for each project are defined, and communicated to the contractor. The contractor then plans, and schedules the workload and required manning to match these requirements. Each project is assigned to an Air Force project manager, who is responsible for monitoring contractor performance. All information concerning cost, schedule, and performance are submitted to both contractor and Air Force project manager. However, only Air Force personnel have access to source data. The Air Force project manager also provides the AEDC customer interface. The contractor does not communicate with the customer directly (Sutton, 1991).

Throughout the year, test workload is revised per customer requests. AEDC Air Force employees collect all workload changes, and communicate them to the contractor.

The contractor then alters plans, schedule, and manning to meet these revised requirements. Because no test projects are defined in the original contract, the flexibility of the contractor comes without any additional penalty. The only additional costs incurred are those caused directly by the changes (additional manning, utilities, materials, etc.) under the cost plus award fee concept (Austin, 1991).

Current AEDC policies and procedures imply that for initial workload, and for all subsequent changes, the AEDC Air Force personnel are primarily responsible for defining requirements, and meeting customer needs.

At NAPC all workers are government employees. The issue of potential conflicts concerning who is managing a project does not exist. NAPC follows the same basic planning routines to determine test requirements. Government employees provide all estimates, management, and customer interface.

The advantage of the in-house workforce, given the detailed procedures at AEDC, is subtle. The key to the success of the process which insures effective management control by government employees is the ability of the AEDC Air Force project manager. If he is skilled and experienced, management control may be effectively held by the Air Force. However, currently, 72% of all AEDC project managers are Air Force officers, with an average of less than 4 years experience (Austin 1991). The contractor project manager, their counterpart, has a great deal more

experience, and is effectively the Air Force project manager. The Navy, by using an all government workforce, eliminates this potential problem.

Increased Dependence on Specific Contractors.

A primary disadvantage of contracting for government services presented in the review of the literature was the dependence on a given contractor over a long period of time creates undue dependence on the contractor labor force. To address this area, data were retrieved concerning the historical contract awardees, and how often these contracts are competed.

AEDC began propulsion testing in 1954. At that time, a sole source contract was signed with Arnold Research Organization, Inc. (ARO) to operate and maintain all center facilities. This arrangement existed until 1977. In that year, the Air Force held a competition for a three year contract to operate and maintain all center test facilities. ARO won that three year contract. In 1979, the Air Force segregated the AEDC effort into the three components it currently recognizes; propulsion testing, flight dynamic testing, and base support. Each effort was competed separately, with no offeror allowed to capture more than one portion of the effort. Three contractors were chosen to provide the AEDC labor force for the period of 1980 - 1985. Sverdrup Technology, Inc was selected to perform the propulsion testing mission. Sverdrup Technology is the company formerly known as ARO. Arvin/Calspan was selected

to perform the flight dynamics testing mission. Pan Am World Services, Inc. was selected to perform the base support mission. This three part competition was repeated in 1985. Pan Am was the only incumbent not to be re-selected. Schneider Services International replaced them. These contracts were in place from 1986 - 1990. In 1990, the three part competition was repeated. This time, all three incumbents were chosen to continue operations at AEDC from 1991 - 1995 (Pickering, 1991).

History indicates that since 1954, contracts have been competed at AEDC a total of only 5 times (Sutton, 1991). These competitions have resulted in even fewer selections of non-incumbent contractors. Sverdrup Technology has been at AEDC, in its current form or that of ARO, throughout the entire existence of the facilities. Calspan has been at AEDC since 1981, and was originally selected, in part, only because a firm other than Sverdrup Technology had to be selected due to the design of the source selection. Schneider Services has been at AEDC since 1986 (Pickering, 1991). Therefore, only once, other than the original, directed, split of the AEDC effort, has an incumbent contractor not been re-selected. During the last source selection, no firms competed against Sverdrup Technology for the AEDC propulsion testing effort. In addition, no firms competed against Calspan for the AEDC flight dynamics testing effort. However, seventeen firms competed for the base support effort (Pickering, 1991).

There were three components of the proposal evaluations by the source selection team. These were the management competency of the contractor, the technical abilities of personnel, and the price of the proposal.

The request for proposal (RFP) directed all offerors to include a directed level of manhours in their respective proposals. In addition, labor rate information for the previous five years was provided to each offeror. The RFP stipulated that (1) winning contractors would be required to hire no less than 90% of the current workforce, and (2) current employees must be hired at no less than their current salary levels. Finally, all award fee bids were directed (Pickering, 1991). As a result, all cost proposals were nearly identical. In fact, there was no competition based on price.

Since all offerors would be required to retain at least 90% of the current workforce, there would be no real difference between the technical capabilities of any offerors. As a result, there was no real competition based on technical ability.

All that remained for evaluation, and differentiation among offerors was management competency. The design of the RFP and source selection may have contributed to a lack of competition for AEDC contracts.

Conflict of Interest.

Another disadvantage of contracting for government services presented in the review of the literature was the

potential for a conflict of interest. To address this area, data were retrieved concerning the number of AEDC contractor employees, with previous DoD experience, and previous DoD/AEDC experience.

Of the entire AEDC contractor workforce, 32% has previous military experience, or previous DoD civilian experience. Of these, 29% have previous AEDC experience. As a result, nearly 10% of the AEDC contractor labor force was previously employed by the Air Force at AEDC. The only mission of Air Force personnel at AEDC is to monitor contractor performance. Former AEDC personnel employed by current contractors range from a personnel clerk to the chief contract officer for one AEDC contractor. In the latter case, the technical director for contracting, a GM-15 position, retired from Air Force service, and was immediately hired as the contractor's chief of contracting. In addition, the general manager of one of the contractors is a retired Air Force Colonel, who was the AEDC base commander for three years (Pickering, 1991). Moreover, the AEDC contractors have no policies prohibiting the hiring of AEDC Air Force personnel. While the number of personnel hired by the contractor in the past is small, the potential exists for a conflict of interest.

There is one more area which requires investigation to answer the second part of investigative question two. The primary drawback of using an in-house workforce at NAPC is the lack of quick response time to customer needs.

Response Time.

This area of concern is very much related to one of the benefits associated with the use of contractor manning at AEDC. Because manning levels and workload are not very strongly related, as previously discovered, the potential exists that a customer requiring test services on short notice, may not be able to have his project completed at NAPC due to a lack of manpower. In 1988, the F-14 fighter developed a problem with its engines. At certain speeds, in certain environmental conditions, the engines would leave a contrail. A contrail is essentially visible exhaust. It appears as a white stream of smoke, which practically points to the aircraft. This increased visibility makes the aircraft more vulnerable. Because of ongoing peak workload at NAPC, the Navy could not schedule testing in sufficient time to meet operational needs. As a result, the work was accomplished at AEDC, with additional manpower, at additional cost to the Navy (McGowan, 1991). While no historical data exists to document exactly how many times this lack of flexibility impacts project scheduling at NAPC, the large number of Navy programs which require testing time at AEDC, as well as other national test facilities, indicates that the stable manning philosophy inherent with an all government workforce has its drawbacks.

V. Conclusions/Recommendations for Further Research

Chapter Overview

This chapter presents a discussion of the conclusions, based on the findings presented in Chapter IV, for each of the two investigative questions. In addition, two recommendations are identified.

Research Purpose

The intent of this research was to investigate the costs and benefits of using contractor labor *vs* government labor in manning two DoD ground test facilities. For the purposes of this study, AEDC and NAPC were compared. The costs and benefits of each alternative manning philosophy were discussed separately.

Conclusions

There are three conclusions which follow as a result of the analysis presented in Chapter IV. First, the average cost per unit of test time is significantly different between the two facilities. Second, marginal total costs and marginal labor costs at AEDC are higher than at NAPC. Marginal costs are the change in costs associated with additional testing. As a result, AEDC appears to be more efficient at lower levels of workload. Third, the subjective evaluation of the benefits of contracting out the labor force at AEDC indicates mixed results. While some of the benefits of contracting out are apparent at AEDC, so are

some of the drawbacks. The assessment is that the benefits associated with the contractor workforce outweighed the drawbacks.

Average Cost Differences.

A review of cost and workload data revealed that cost per air-on-hour is higher at NAPC than at AEDC. Figure 7 shows the relationships for a comparable time period, from 1976 - 1990. NAPC costs per air-on-hour, for various levels of workload, are grouped, and higher than AEDC cost per air-on-hour figures for similar levels of workload. Regressions of total cost, labor cost, and workload data for both facilities, presented in Chapter IV, explored possible reasons for this difference. Table 16 and Figure 8 show a breakout of average total cost per air-on-hour, by category. While labor costs represent similar proportions of total cost for each facility (AEDC - 75.2%, NAPC - 74.9%) the relationship between labor cost and workload, and total cost and workload differed between the two facilities. Total workload for AEDC was an excellent predictor of both total cost and labor cost. Total workload for NAPC failed to explain variations in total cost or labor cost. In addition, statistical tests on a combined dataset, using indicator variables, demonstrated that the causal relationship between total cost and workload differed significantly between the two facilities. The final result of tests performed in Chapter IV is that, using a total cost approach, AEDC costs less per unit of workload.

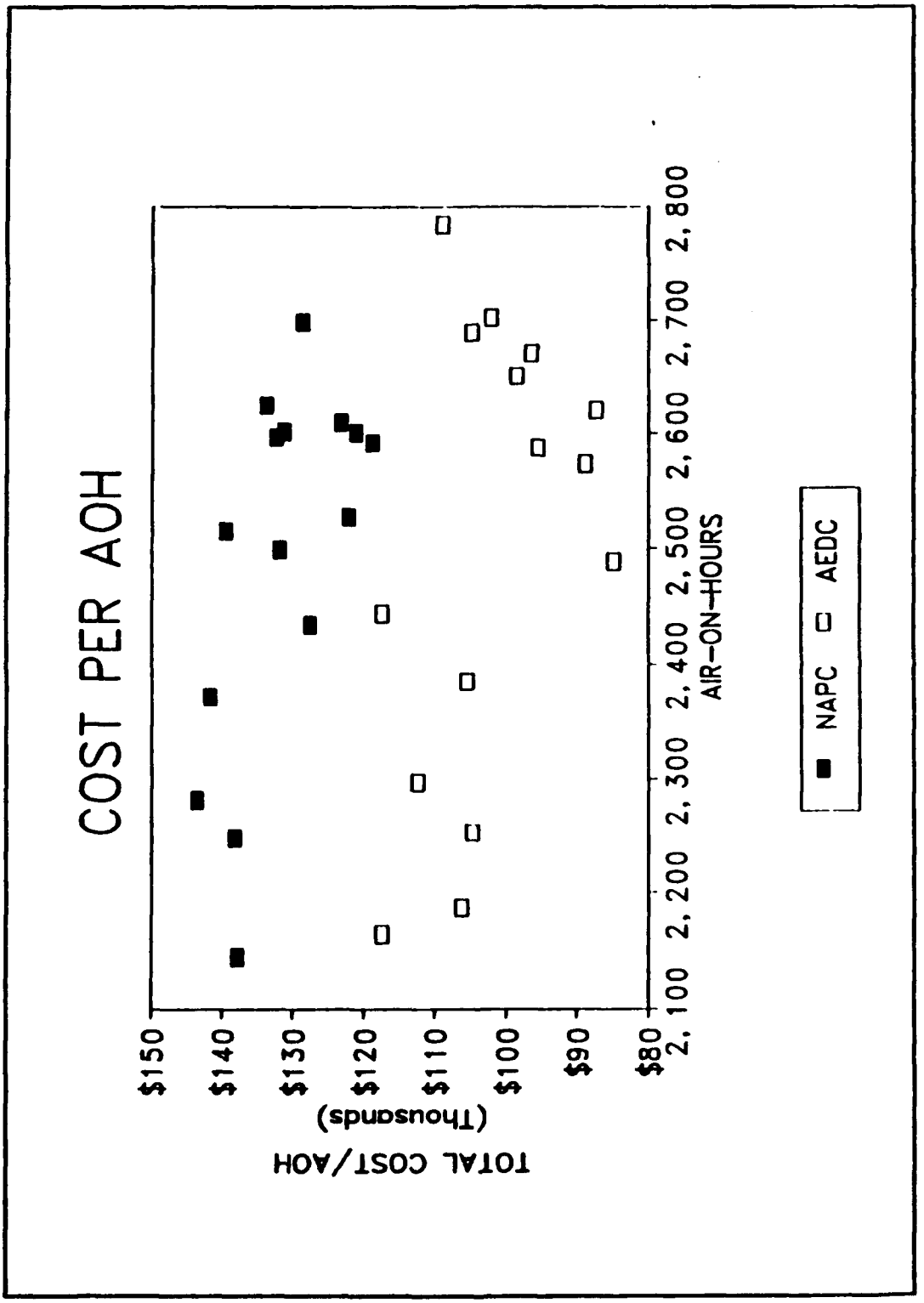

Figure 7. COST PER AOH COMPARISON

TABLE 16

AVERAGE COST/MARGINAL COST COMPARISON: BY COST CATEGORY

	NAPC		AEDC	
	Average	Marginal	Average	Marginal
Labor	$81,548	$ 669	$68,065	$40,087
Materials	19,162	22,083	15,749	9,564
Utilities	6,533	5,315	5,249	3,112
Other	1,633	1,706	1,357	768
Fee	0	0	905	19.3E-6

Marginal Cost Implications.

A comparison of average versus marginal costs for AEDC and NAPC is presented in Table 16. Total costs and labor costs for each facility were estimated using the regression equations presented in Tables 3, 4, 8, and 9. Figure 9 presents the projected total costs and labor costs for each facility at workload levels varying from 2,100 to 2,700 air-on-hours. For each set of regression equations, the slope term (representing the marginal costs) for the AEDC equations is larger. As a result, when workload increased, NAPC became relatively less expensive. As workload decreased, AEDC became the low cost option. In addition, NAPC labor costs changed little as workload changed due to the extremely small marginal costs. There are three possible sources for the differences in cost. The first is that AEDC appears to have greater flexibility in varying

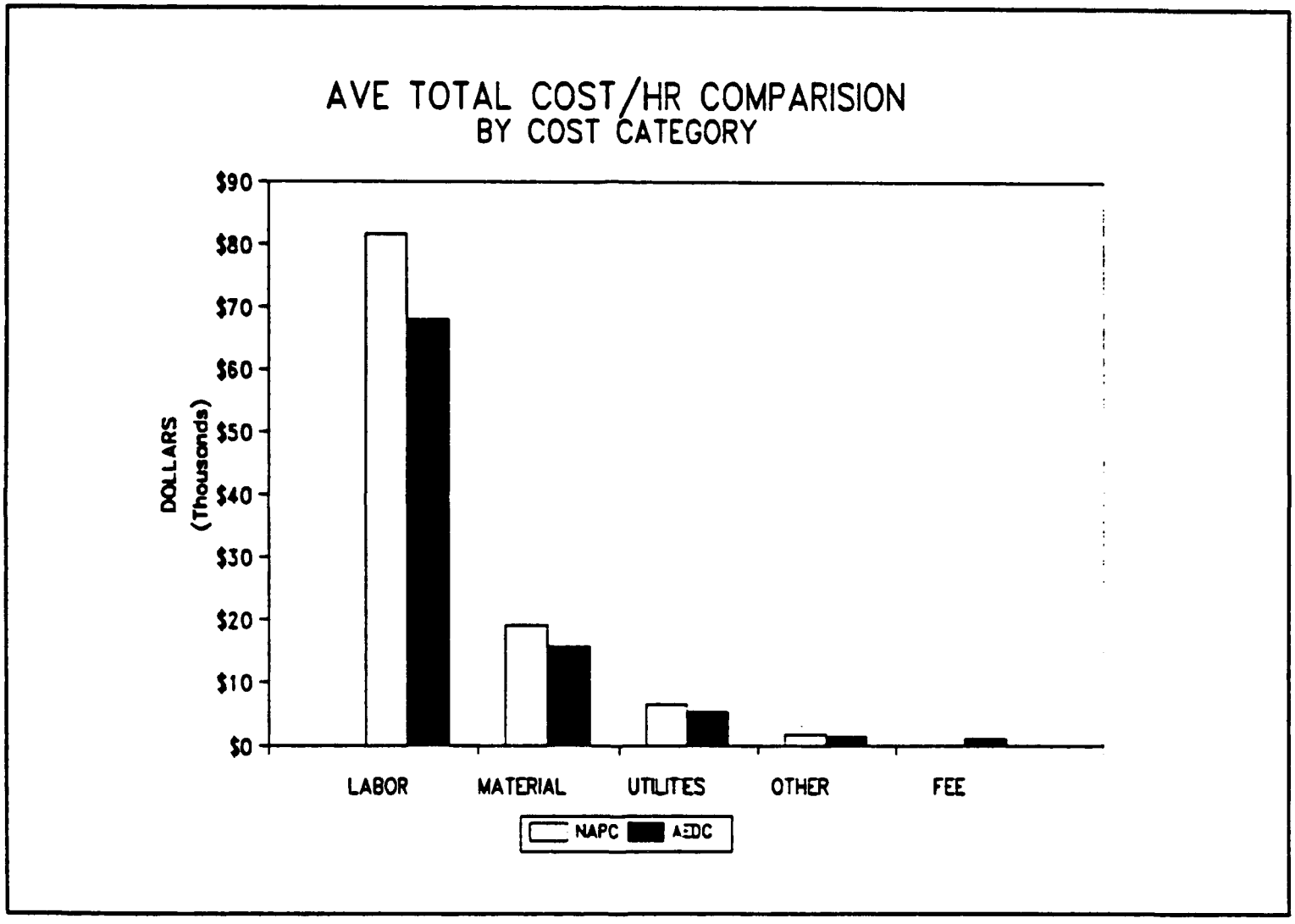

Figure 8. AVERAGE COST COMPARISON: BY CATEGORY

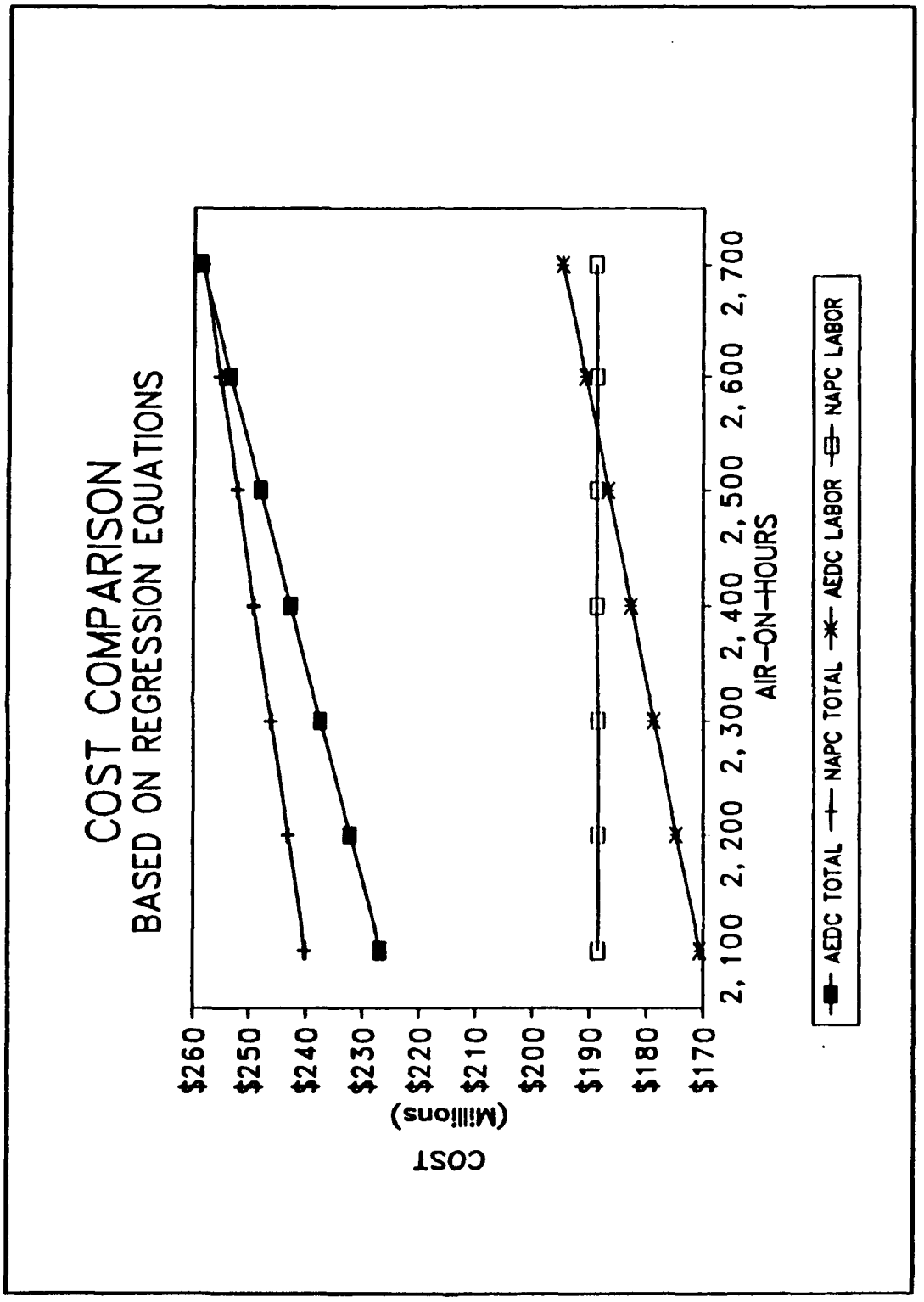

Figure 9. MARGINAL COST COMPARISON

manpower as workload varies. This avoids the expense of paying employees who cannot be productively employed when workload decreases. A second possible explanation is that AEDC not only has flexibility in varying the quantity of manpower to meet varying levels of workload, but also the ability to vary the composition of the workforce. Third, wage rates differ between the labor forces employed at the two facilities. Specific labor rate data for NAPC reveal the average wage to be $26.28/hour. This constant, FY 90 dollar figure includes prorated fringe benefit costs. The comparable AEDC labor rate is $29.25/hour. Given a similar level of workload and manning, AEDC would yield higher labor costs than NAPC, based on average labor rates alone. It appears that the variation in level and composition of the workforce to meet variations in workload more than offset AEDC's higher labor rates.

NAPC workload showed relatively less variation. The coefficient of variation is a statistical measure of the variation within a dataset. An analysis of AEDC workload revealed a coefficient of variation of 12.3%. This means that 68% of the workload observations were within 12.3% of the mean workload. For NAPC, this value was only 6.45%. Thus, NAPC workload exhibited less variation than AEDC workload. Workload may not vary over time because of possible NAPC capacity limitations. In any case, the lack of relative variability of NAPC workload qualifies the cost results obtained in Chapter IV. Because the regression

equations for the NAPC dataset were not statistically significant, the estimated marginal costs (slope terms) for total costs and labor costs are not very reliable.

Benefit Comparison Results.

Eight different benefits, or lack thereof, were identified, and assessed. These were (1) the number of errors which cause work to be re-accomplished, (2) the flexibility in manning to meet required workload, (3) the level of specialization and expertise of the workforce, (4) the existence of innovations, (5) the level of management control by government employees, (6) the level of dependence on specific contractors, (7) potential conflicts of interest, and (8) the responsiveness of each labor force to customer requests. Table 17 summarizes the benefits evaluation findings. Compared to NAPC, AEDC was found to have fewer errors, greater flexibility, and the most qualified employees. However, AEDC increases Government dependence on the private sector, and presents more opportunities for conflicts of interest. Comparisons of innovation, customer responsiveness, and management control were inconclusive.

Overall, the evaluation of benefits suggests that some of the benefits and drawbacks associated with a contractor labor force do exist at AEDC. The drawbacks are primarily concerned with ethical issues, and as a result, their focus is internal to the organization. The benefits' focus is external and relate to business operations. The impact of

TABLE 17

SUMMARY OF BENEFIT EVALUATION

BENEFITS:	FINDING
Fewer Errors	AEDC
Greatest Flexibility	AEDC
Highest Employee Qualifications	AEDC
Extent of Innovation	Inconclusive
Responsiveness to Customer	Inconclusive
DRAWBACKS:	
Possible Management Control Problems	Inconclusive
Most Dependence on Private Sector	AEDC
Most Potential for Conflict of Interest	AEDC

the drawbacks would be to (1) offset any supposed benefits, and (2) increase overall total cost. Because AEDC costs are lower than NAPC, and because some of the benefits do exist, the subjective assessment of using the contracted labor force at AEDC is that the benefits outweigh the drawbacks.

Recommendations

There are two recommendations as a result of this research. The first addresses the issue of a total cost vs marginal cost comparisons of DoD test facilities. The

second addresses the potential pricing implications for funding of DoD test facilities.

Total Cost/Marginal Cost Perspective.

This study was performed using a total cost perspective. As a result of the DoD/IG investigation mentioned in Chapter I, AEDC has gained a reputation as a relatively high cost test facility. The comparison was incomplete. When all costs are considered, this research showed AEDC to have overall lower average total costs than NAPC. Any comparisons between test facilities should be made on an equitable basis.

Pricing Implications.

Current DoD guidance concerning the funding for test facilities requires program offices to fund some of the fixed costs. In addition, each program office can choose which test facility it wishes to perform required test services. According to the economic principle of allocative efficiency, customer price should equal the marginal cost (the cost of additional work). These costs should include NO fixed costs. Fixed costs should be funded separately and should not be considered in the decision to test at AEDC or NAPC. The most efficient use of resources requires that customers pay only the marginal costs, since those are the only costs which vary with an additional test. Charging customers based upon average costs can easily result in work being done in a location where the true costs of the test is higher. Inflation adjusted marginal test costs have been

estimated in this thesis. Further study is required to determine the impact of implementing such a marginal cost based funding policy for DoD test facilities.

Appendix A: AEDC Cost Data

FY	LABOR	UTILITIES	MATERIAL	OTHER	FEE	TOTAL
54	$92,697,739	$19,980,666	$7,676,511	$1,643,388	$8,098,771	$130,097,074
55	107,213,015	28,225,385	8,001,788	2,478,774	8,261,176	154,180,138
56	117,521,299	22,665,373	8,974,755	1,936,743	7,848,290	158,946,461
57	132,823,552	35,938,464	10,941,684	3,104,630	7,548,550	190,356,880
58	125,762,576	25,827,245	9,728,796	2,040,614	8,200,423	171,559,655
59	144,750,744	34,079,360	13,305,935	3,453,113	7,886,716	203,475,868
60	147,796,975	31,229,080	9,578,110	2,326,979	8,122,413	199,053,558
61	160,001,728	35,528,324	12,066,765	3,713,960	8,171,412	219,482,189
62	170,830,946	33,728,378	11,967,243	2,799,580	7,614,997	226,941,144
63	188,807,966	46,468,090	14,099,479	4,405,223	8,148,939	261,929,697
64	198,265,934	37,839,897	13,207,616	3,225,439	8,152,273	260,691,159
65	209,336,851	49,860,292	16,031,917	4,383,622	8,443,603	288,056,286
66	210,665,313	54,967,380	17,239,922	3,930,907	8,018,335	294,821,857
67	224,096,003	51,683,681	16,085,843	4,775,112	8,325,574	304,966,212
68	204,568,795	52,039,431	16,399,948	3,741,907	7,699,303	284,449,384
69	199,033,465	40,373,535	16,373,626	4,254,689	7,838,149	267,873,464
70	182,731,461	42,314,799	13,489,236	3,329,962	8,366,289	250,231,747
71	165,614,809	33,746,347	11,739,018	3,537,313	8,468,898	223,106,386
72	154,708,000	38,974,613	11,825,334	2,822,081	7,616,640	215,946,668
73	175,910,397	43,895,717	13,092,985	3,869,805	8,419,241	245,188,145
74	173,409,641	40,096,837	14,507,692	3,052,232	7,983,605	239,050,008
75	183,471,044	45,723,169	16,827,800	4,372,557	8,389,319	258,783,888
76	181,925,779	36,135,056	11,501,854	2,868,534	8,215,759	240,646,982
77	170,256,068	47,521,936	13,734,204	4,183,697	7,837,051	243,532,956
78	164,530,486	32,746,153	11,444,090	2,472,407	8,404,679	219,597,814
79	171,102,780	41,066,008	12,799,888	3,732,100	7,579,383	236,280,159
80	172,905,734	38,741,677	13,854,828	3,075,643	7,639,949	236,217,831
81	188,461,821	44,997,890	16,640,226	4,177,597	7,567,661	261,845,196
82	193,687,659	45,476,270	15,618,975	3,376,596	8,432,093	266,591,594
83	206,830,981	55,448,687	19,469,236	5,267,985	8,375,092	295,391,981
84	203,472,874	38,182,447	13,244,919	2,875,074	7,603,999	265,379,314
85	202,454,996	54,136,303	20,311,857	5,102,221	7,569,982	289,575,360
86	204,943,676	40,010,360	13,426,223	2,950,831	8,147,295	269,478,385
87	216,001,111	61,639,647	20,470,823	5,342,223	8,401,403	311,855,207
88	195,966,817	34,594,341	13,809,988	2,913,561	7,609,467	254,894,174
89	206,204,297	48,718,515	16,728,744	4,269,272	8,281,541	284,202,369
90	185,913,409	47,684,428	14,534,689	3,513,006	8,357,801	260,003,333

Appendix B: NAPC Cost Data

FY	LABOR	UTILITIES	MATERIAL	OTHER	TOTAL
76	$188,847,732	$49,325,919	$16,034,612	$4,535,579	$258,743,842
77	188,415,664	38,019,928	13,847,117	2,961,154	243,243,863
78	191,931,418	59,751,876	18,921,118	4,948,076	275,552,487
79	185,590,935	31,236,002	11,101,550	2,181,305	230,109,791
80	191,108,030	57,503,803	18,701,172	5,013,238	272,326,243
81	188,099,018	29,191,135	11,388,166	2,406,639	231,084,957
82	190,774,707	52,423,085	17,105,994	4,484,360	264,788,146
83	185,180,082	36,730,547	12,728,180	2,884,309	237,523,118
84	190,432,792	54,779,317	17,013,026	4,448,200	266,673,334
85	187,862,331	33,708,364	12,974,011	2,673,953	237,218,659
86	188,222,513	54,238,979	18,509,268	4,805,702	265,776,462
87	186,461,081	32,518,899	11,199,383	2,683,025	232,862,388
88	189,972,246	45,083,300	15,429,268	4,298,309	254,783,124
89	185,562,610	40,116,010	14,321,996	3,223,627	243,224,242
90	190,366,291	52,038,897	16,654,429	4,492,052	263,551,670

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Vita

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13. ABSTRACT *(Maximum 200 words)*

This study compared the costs and benefits of the manning structure of two DoD ground test facilities, Arnold Engineering Development Center (AEDC) and the Naval Air Propulsion Center (NAPC). Total costs included all fixed and joint costs for each facility. The purpose of the study was to determine (1) the existence and extent of cost differences between the two facilities, (2) reasons for these cost differences, and (3) their impact. The results indicate that AEDC is a lower cost facility, on a total cost basis. This lower cost is primarily a function of varying manning to meet required workload. In addition, AEDC has both higher marginal total costs and higher marginal labor costs. As a result, AEDC is more efficient at lower levels of workload. A literature search revealed several possible benefits, or lack thereof, associated with using private sector labor to accomplish government tasks. A subjective evaluation of historical data, and current procedures was made to determine if these applied to the labor force at AEDC. The overall assessment was that some of the benefits and drawbacks do exist. The impact is that the benefits outweigh the drawbacks. 251

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